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Ref: SC Mag July 2012

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Refer: Silicon Chip Magazine June 2011

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Contents

SILICON CHIP

Vol.25, No.9; September 2012 www.siliconchip.com.au

Features

12 Electronex: The Latest Smart Electronics
Electronex returns to Sydney's Australian Technology Park from 12-13th September and entry is free for SILICON CHIP readers – by Ross Tester

16 Review: Virtins Technology Multi-Instrument 3.2
This software package turns your PC into a 2-channel audio scope, a powerful spectrum analyser, a signal generator and lots more – by Jim Rowe

61 The HRSA's 30th Birthday
They specialise in bringing old radios back to life and this month, they're celebrating their 30th birthday with a show in Melbourne – by Kevin Poulter

92 Review: iModela 3-Axis CNC Router/Mill
It's small, it's low cost and it may be just what many hobbyists have been looking for – by Nicholas Vinen

Projects To Build

22 Colour MaxiMite Microcomputer, Pt.1
How do you improve on the original MaxiMite Microcomputer? By using a new PIC32 chip, adding an Arduino connector and adding eight vibrant colours plus a stereo music synthesiser – by Geoff Graham

30 Barking Dog Blaster: Shut That Annoying Mutt Up!
Driven mad by a barking dog? Don't get mad, get even. This unit operates above the range of human hearing and may help shut that mutt up – by John Clarke

40 USB Test Instrument Interface For PCs
Turn your PC into a whole suite of test instruments with this USB interface plus some free software. There's a 2-channel scope, spectrum analyser, frequency counter and a signal/function/arbitrary waveform generator – by Jim Rowe

70 Digital Sound Effects Generator
Versatile module can play back up to eight different sound tracks. It's ideal for use with model railway layouts and other application requiring sound effects and you can download the sounds from a PC via USB – by Nicholas Vinen

Special Columns

64 Serviceman's Log
Outsmarted & frustrated by smartphones

82 Circuit Notebook
(1) Simple Sound & Light Alarm; (2) Low-Voltage LED Lighting System Has Remote-Controlled Dimming; (3) Bilge Pump Time Extender; (4) Induction Motor Centrifugal Switch Over-ride; (5) Simple Metal Locator; (6) Compensated Probe Measures Peak Mains AC Voltage

98 Vintage Radio
A "vintage" radio from just a front panel – by Graham Parslow

Departments

2 Publisher's Letter
4 Mailbag
52 Product Showcase
105 Order Form
106 Ask Silicon Chip
111 Market Centre
112 Notes & Errata

Note: due to space constraints, Pt.2 of the RPA story has been held over until the October issue.

Colour MaxiMite Microcomputer, Pt.1 – Page 22.

Barking Mad: Shut That Annoying Mutt Up – Page 30.

USB Test Instrument Interface For PCs – Page 40.

Digital Sound Effects Generator – Page 70.

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Publisher's Letter

We need the NBN; pity it's so expensive

As readers will be aware, I have criticised the National Broadband Network in a number of past Publisher's Letters, mainly on the issue of its huge and open-ended cost. The correctness of that criticism has been borne out by the recent report of NBN Co, detailing lack of progress, further cost increases and pitifully low number of people actually connected and using it, at under 4000.

But while I lament the process by which it has come about, I have concluded that we really do need the NBN. Why? Because it is painfully obvious that the vast majority of businesses in Australia are now irrevocably tied to the internet. The internet is wonderful when it is running and it is now inconceivable that we could do business without it. When the internet is down, for whatever reason, our VOIP PABX does not work, we have no email, we can't transfer files, do any financial transactions and so on.

So we need a reliable internet connection and I dare say that would apply to virtually all businesses now. The connection does not have to be particularly fast but it does need to utterly reliable. And looking back, I don't think Telstra would ever have planned for a complete optical fibre network covering virtually all of Australia and with "fibre to the home" (FTTH). Telstra's preferred lower-cost option was always "fibre to the node" (FTTN).

Unfortunately, FTTN is always going to be dodgy because it relies on the obsolete copper wires in Telstra's ducts for the connection from the "node" to the home. The simple fact is that those wires and ducts have been there for decades, maybe 60 years or more, and Telstra has done virtually no maintenance for years. The situation in my own suburb of Collaroy Plateau is a classic case. Because so much of the suburb is hilly and rocky, much of the copper network is strung pole-to-pole, as are the Pay-TV cables for Foxtel and Optus.

These cables are a mess and every time we have a few days of bad weather, we either have a failure of the phone or a very noisy connection, coupled with no internet or lots of drop-outs. Or sometimes we might lose the phone but the internet still runs, indicating that one of the cable pair is open-circuit or there is a poor connection somewhere. Many of my neighbours have similar problems. One particularly unfortunate Telstra customer living close by has had no fixed line for about seven weeks but has had the internet during all that time. And Telstra has not been able to fix it, despite a number of visits by technicians.

So as far as Collaroy Plateau is concerned, FTTN, if it ever happens, will be a joke. We will still be relying on the rubbishy cables in the street! While much of Telstra's network is probably not as bad, it is not likely to provide the high reliability that should be available from a brand-new optical fibre-to-the-home network. It cannot come soon enough, as far as I am concerned.

Mind you, a lot of people do not have any land-line phone or internet connection; they rely on their mobile phone for all communications. At the last count, about 14% of Australian households were in this category and it is increasing. Well, that is all well and good but mobile phones aren't utterly reliable either, as you will sometimes find on critical occasions. I also have an Android mobile phone and can use it for email, internet etc but it is not a complete substitute for a land-line, the faster 4G service notwithstanding.

In fact, all businesses and most people probably need both: utterly reliable mobile and fixed-line communications. I wonder how long it will be before we get it.

Leo Simpson

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Possible technique for muting TV adverts

The Publisher's Letter in the February 2012 issue concerned the annoying loudness levels of TV commercials. This was prompted by information on the introduction of the US Commercial Advertisement Loudness Mitigation Act (CALM) aiming to "make sure that the volume on commercials is kept in check."

Following a pessimistic assessment of the possibility of similar regulations working in Australia and of the counter-productiveness of advertising agencies continuing to alienate customers by use of loud commercials, readers were encouraged to "turn the TV off" as a protest.

Subsequent Mailbag responses highlight the key issues as community annoyance at the intrusive nature of commercials, the issue being of apparent loudness not peak volume levels, the standard practice of compressing peaks in dynamic range so that the volume of most signal content can be raised to high levels and thus increase apparent loudness and the need to develop strategies to measure loudness as opposed to peak and average dB.

As Noel Bachelor (Mailbag, August 2012) has pointed out, much has been accomplished in developing international and Australian standards and the technology for measuring loudness.

The US CALM legislation is the outcome of extensive research by the International Telecommunications Union (ITU). In work of similar significance to that in developing the decibel scale for human hearing, the ITU used extensive human testing to develop an algorithm providing a good approximation to human loudness perception of program audio.

This is based on measuring audio power over time and allows broadcasters to control loudness of audio material using loudness measuring techniques to supplement level measurements. The measure can be applied to, say, a 30-second advert or a 90-minute program.

Of local significance, the Free TV Australia consortium publishes Operational Practice standards that are based on the ITU standards. OP-59 July 2010 is to be enforced by the end of 2012.

Under OP-59, the new ITU unit of loudness for program content requires a loudness level of -24LKFS and True Peaks not exceeding -2dBFS. (L – loudness; K – the unique filtering of the

Nissan Leaf is too expensive

With respect to your story on the RTA and school flashing lights (SILICON CHIP, July 2012), I've worked in big organisations. Over and over I saw that phenomenon you describe where the RTA insisted on installing flashing lights that cost $58,000 rather than Peter Olsen's ones that cost $1400. There'd have to be a committee of all the "stakeholders" and endless meetings where everyone around the table would demand some feature relating to their area of responsibility and none would concede that it wasn't vitally important. And no-one around the table considered the cost. That was someone else's problem.

Everywhere you look in the technology area you see there is one product aimed at consumers that just does the job the customer wants and another for "enterprise" customers that costs many times more and is loaded up with rarely used and/or largely useless features that end up making it harder to use and less reliable.

That's what scares me about the NBN. I look at the unit that is being installed at each premises and it was obviously designed by exactly that sort of process; no-one at the table considered the cost to be their problem and no-one spoke for the customer and what they want.

With respect to the review in the August 2012 issue, Ross Tester says that the Nissan Leaf accelerates as quickly as a 3-litre V6 car. In fact, its actual measured 0-100km/h performance time of 11.9 seconds only about matches the cheapest 1.3-1.5 litre 4-cylinder cars on the market that only cost a third as much.

A 3-litre V6 Commodore takes about 7.7 seconds to get to 100kmh. If you're happy with a 12-second 0-100km/h time you could buy a Ford Fiesta Econetic that only uses just over 3l/100km of fuel, emits less carbon dioxide than the power generators would to produce the electricity to charge up the Leaf, wouldn't have the issues with very limited range the Leaf has and would cost less than half as much to buy.

Ross Tester enthuses about how filling the Leaf up at a charging point only costs $2-$10 compared to filling up a car with petrol which costs $50-$70. But he fails to mention that you only have to fill up a petrol car once a week but you have to fill up the Leaf every day. And if every single day you can't find a charging station or someone else is using it, or some prankster or someone else who wants to charge up their car unplugs yours, you'll have a very expensive and delayed trip home on the back of a tow truck.

The Leaf specifically and electric cars generally are still a long way from being a practicable and economic replacement for petrol and diesel-powered cars.

Gordon Drennan,
Burton, SA.

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Mailbag: continued

Error in explanation of series circuit

With reference to your article entitled "Modifying An Urn To Save Power" (SILICON CHIP, July 2012, page 60), there are technical errors in your explanation of the series RC circuit.

Your statement : "Note that if you simply multiply the current draw (228mA) by 230VAC you get a figure of 52.5W" is not correct. This value is the Apparent Power, expressed in Volt-amperes and should be written as 52.5VA.

The explanation continues ". . . it represents both 15.6W of real power and 36.9W of imaginary power" is also wrong. Firstly, imaginary power is expressed in volt-amperes reactive and will be written as Vars. Secondly, the capacitive and resistive components' voltages are out of phase by 90° (ignoring small losses in the capacitor) so that the total volt-amperes value is the vector sum of the real power in Watts and the reactive power in Vars. The imaginary power cannot be calculated by simply subtracting the value of real power from the total power. The imaginary power is found from the following formula:

Vars = $\sqrt{(VA^2 - W^2)} = \sqrt{(52.5^2 - 15.6^2)}$ = 50.129 Vars of imaginary power. This is in accordance with the power triangle.

Thus, you cannot simply add the values of Watts and Vars to get the total power, as they must be added vectorially.

T. Ives,
Penguin, Tasmania.

Comment: you are correct. The guilty party has been sentenced to six lashes with a length of Cat8 cable.

algorithm; FS – full scale (digital)).

The concepts, standards, methodology and technology to manage loudness issues are now available. Time will tell whether optimism about self-regulation by the Australian broadcast industry is warranted, as opposed to pessimism about a US-style regulatory approach.

On the subject of a possible project for detecting commercials and muting or dropping volume, I understand that OP-48 requires Australian networks to precede commercials with a 1kHz tone indicating the normal level of the following audio material – **http://ses.library.usyd.edu.au/bitstream/2123/8458/2/Final%20Review%20-%20GCuthbert.pdf**

What are the chances of such a project being developed, as the frustration levels suggest it would provoke a lot of interest?

David George,
Montmorency, Vic.

Uncluttered PC plus new modem improves ADSL speeds

In my article about ADSL in the May 2012 issue, I mentioned that at 167 metres line length from my nearest telephone exchange I was achieving download speeds of between 10Mbit/s and 16Mbit/s on what I thought was poor grade copper. Some readers in the know may feel this is rather low. They would be right!

Since then, I have built up a modestly-configured Windows 7 machine. Windows 7 is a vast improvement on XP (and certainly on Vista!) but that is another story. I also took the opportunity of putting in a new modem. I am now happy to report that I achieve download speeds of 18Mbits/s and over on a continuous basis. I attribute that mainly to a new and uncluttered computer system.

Alan Ford,
Salamander Bay, NSW.

Novel concept for solar hot-water system

I have always dreamed of a preheater for my hot-water tank. The plumbing and frost here dampened the project. I purchased two cheap 12V 50W solar panels with the idea of running a small charger/inverter for 240V.

My hot-water tank has a 4.8kW element, ie, about 12Ω, so if it is powered from the panels, 10 hours of sun gives about 500 watt-hours of preheat. After a trial connection, I managed a solar shower, in autumn, yet the water was still warm next morning.

Developing the project further, a relay would change from 24V DC to 230VAC at off-peak or boost times. I expect my power bill to be reduced, even with the carbon tax increases on top of increases this year. The primary idea is to show that a 24V solar array can provide about 500 watt-hours of heating.

Jim Hewson,
Kyneton, Vic.

Comment: we would be very wary about doing this sort of thing because it would require modifications to fixed mains wiring. However, the concept is of considerable interest for those people who want to be independent of the grid and do not want a heavy solar collector and tank on the roof.

Your concept could be extended to having the tank solely powered by a 1kW (say) solar panel array. This could easily power a large hot-water tank and the beauty of it is that there is no need for an inverter, plumbing etc.

Caution on PC power supply circuit

As a frequent user of recycled PC power supplies I was surprised to see the Circuit Notebook item using two supplies in series to give 24V but no mention was made about internal and external grounding! I have found that the ground connection (0V) is connected to the case and via the power connector to any other device which is grounded via the earth wire. Thus there would be a dead short across both supplies.

The DC outputs MUST be isolated from the case, allowing them to float. The corner screws of the PCB are often connected to 0V and via the screws to the case. To do this the supply must be disassembled and as we know there are some very dangerous voltages inside these supplies.

No warning was given with this circuit! I have not tried this and there may be other considerations.

Martyn Davison,
Paynesville, Vic.

Comments on the Square Kilometre Array article

I write to correct an inaccuracy in your report on the Square Kilometre

Array (SKA) site decision (SILICON CHIP, July 2012). Geoff Graham has misunderstood the position concerning SKA-low, the part of the SKA covering the frequency range 70-450MHz. SKA-low in its entirety will be built in Western Australia and SKA-low Phase 1 – representing about 10% of the final low-frequency array – will be built from 2016 onwards, not from 2020 onwards as your writer states. SKA-low in its final form will consist of several million active antennas.

Phase 1 will contain hundreds of thousands of these elements and be a true software-defined telescope, the capability of which is limited only by the associated ICT investment. Far from being "less important", SKA-low covers much of the Early Universe science from which the international SKA endeavour was born.

I believe your writer is confused by the mix of base and advanced technologies in the SKA project. Dishes with single-pixel (conventional) feeds and "sparse" aperture arrays have long formed the base technologies which I, in my former role as SKA International Project Engineer, helped define. These receptors are the main constituents of SKA Phase 1 and form the default technologies for its mid (>450MHz) and low-frequency (<450MHz) bands, respectively.

In parallel with optimisation of base systems, two other exciting technologies are being brought to maturity: dishes with Phased Array Feeds (being proven by the Australian SKA Pathfinder and the Dutch APERTIF program), and "dense" aperture arrays. These advanced technologies both operate above 450MHz. With considerable investment in Phased Array Feeds, this particular technology is maturing quickly, and the international community has elected to back an SKA Phase 1 survey instrument incorporating ASKAP. This is in ad-

CDI module design recommended

I recently encountered the May 2008 article in SILICON CHIP on building replacement CDI modules for small petrol motors. I would like to compliment you on an excellent article!

I have some specific information which might be of use to your readers. In the US, the generic CDI module was a hybrid between your "basic" and improved circuits. Diode D4 is added to your basic circuit. The 51Ω gate limiter is 27Ω and the gate return is increased from 1kΩ to 2kΩ. The 0.1μF SCR gate-cathode bypass capacitor was not used. The discharge capacitor was typically 1μF 200V.

These units were produced in the tens of thousands and have a demonstrated MTBF of about 20 years! The Wisconsin YJ69 used on the S12D and S14D is a good example. They are now much sought after since they have not been available for many years!

Dale Smith,
Troy, Ohio, USA.

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Mailbag: continued

Surge currents caused relay contact failure in mains timer

Back in April 2012, your magazine presented an excellent article and project on the Mains SoftStarter. At the time, little did I realise that I too would have a similar problem to the problems others have experienced.

We have an LCD TV in the bedroom, on a timer to basically only work when needed. Also, the front panel indicator is alight whenever power is on and this is a bit annoying in the dark. Then add to that the power consumed when in standby mode; hence the timer.

Well, all has been well until the timer decided to pack it in and this I deduced is because the relay contacts have welded and I put this down to the excessive current splat at turn-on you have mentioned. The relay has 16A-rated contacts but this isn't sufficient to handle the SMPS splat of the TV, it seems. I will have to build this project and you are to be congratulated on how well it works.

But if this is a known problem with switchmode supplies, why haven't the manufacturers been approached to remedy this with some soft start feature like in this project? Also, I believe that they should have some moral obligation to recognise that they are causing these problems and take steps to alleviate the issues of excessive currents as the input capacitors charge up or alternatively, be made to do something about it, as this is going to get worse in the future.

Brian Collath,
Moss Vale, NSW.

Comment: as far as we know, there is no obligation on designers and manufacturers to do anything about switch-on surge currents or mains waveform distortion.

dition to the larger Phase 1 and Phase 2 dish arrays in South Africa.

For an electronics-literate audience it might be worth expanding a little on the SKA aperture arrays. Sparse and dense aperture arrays share many operational properties but the main technical difference is the amount of mutual coupling experienced by elemental antennas. Sparse arrays are very effective at low frequencies because the effective area grows as roughly the wavelength squared, giving a highly sensitive SKA-low in the face of a nearly-equivalent background noise increase from the Milky Way.

Dense arrays, which are likely the ultimate future of radio astronomy and many other radio engineering fields, are more like a dish in that they maintain a constant effective area, albeit with enormously more flexibility. Both sparse and dense arrays allow the collecting area to be re-used: simultaneous, truly independent beams can be pointed anywhere on the sky.

One difference between the two technologies is the ease with which high-fidelity radio images of the sky can be produced; dense arrays may offer advantages in this regard. Against this, dense arrays oversample the incoming wave-front, requiring orders of magnitude more elemental antennas and consequentially higher cost than the already-challenging sparse arrays.

The working concept for SKA-low antennas has been drooping dipoles but a global consortium is developing what are likely to be more attractive solutions, perhaps based on a mix of log-periodic and dipole technologies. The International Centre for Radio Astronomy Research (ICRAR), a Perth-based joint venture between Curtin University and UWA, is a leading consortium member and will have responsibility for much of the SKA-low design and verification.

Two major pathfinders (LOFAR and the Murchison Widefield Array) are operational and are providing the science and engineering stepping stones to SKA-low. Indeed, the Curtin-led MWA is located at the Murchison Radio-astronomy Observatory, near the CSIRO ASKAP dish instrument. Its infrastructure will be used by the SKA-low consortium as a platform

for medium-scale (10,000 element) verification systems to be built by ICRAR and its partners during the next three to four years. While there are some challenging system design and performance-cost issues to address, SKA-low is on track for deployment as part of SKA Phase 1.

Those of us working closely with international partners, in what is one of the most exciting mega-science projects of the century, are looking forward to having SKA-low (and the survey telescope) on our doorstep in WA. World financial crises make science funding of any sort a challenge but the all-important European SKA partners, motivated in part by the need to innovate their way out of present difficulties, remain committed firmly to SKA-low and its development in Australia.

Flowing from this, there will be many opportunities for Australian R&D and industry, and part of ICRAR's mission in leading the Australian SKA-low activities is to continue to build the links needed to realise the benefits.

Finally, the SKA Organisation Board has made it clear that development of Phase 2 facilities in Australia and South Africa is contingent on the success of Phase 1 instruments. This is an effective risk mitigation strategy but also serves to remind those of us involved with delivering the SKA that there is no room for hubris or jingoism in this endeavour; there's plenty for both host nations to prove and challenge enough for all our international partners.

Peter J. Hall,
Professor of Radio Astronomy Engineering,
Deputy Director, International Centre for Radio Astronomy Research (ICRAR),
Curtin Institute of Radio Astronomy, Perth, WA.

Science syllabus is cause for dismay

I know that it all depends on whatever floats your boat but to me, the July 2012 issue of SILICON CHIP is one of the best, if not THE best issues ever. It is chock full of great features and constructional projects.

As a long-time railway modeller (to the point of lunacy, I sometimes think), the DCC booster is of course, a stand-out project. I have not yet experimented with DCC but articles such as this project and the February 2012 guide are certainly encouraging me to investigate this method of control. I model in N scale and the latest locomotives being produced are DCC-ready.

Whilst I'm not into model aircraft (my love of trains is bad enough), Serviceman Dave Thompson's piece about converting DVD motors is another stand-out. It appeals to my own nature of not liking to throw good stuff away. Much of the under-board electronics and wiring on my train layout was scrounged from old VCRs and the like.

The Capacitance Substitution Box, Wideband Oxygen Sensor and Power tool Soft-Starter too, are all worthwhile projects. Heck, even the advertisements from the regular firms are full of really good hardcore electronics stuff this month!

Finally, as a semi-retired physics teacher, I found the article on Peter Olsen's school lights fascinating but at the same time, mind-numbing. Sometimes the staggeringly stupid decisions made by governments is enough to make one despair. I had to read the bit about the RTA ripping out Mr Olsen's signs several times for it to sink in! Unbelievable. In relation to this, I loved the comment made at the end of the Publisher's Letter about one person at the road work actually doing the work while all the others looked on. That situation would often occur in my high school science practical classes, when I would make the comment that "you kids have got county council syndrome".

It is a fantastic issue and a credit to everyone involved. Keep up the good work!

A a semi-retired HSC physics teacher of some 25 years, I feel I must also comment on the Publisher's letter in the August 2012 issue. I was aware that a new science syllabus was being planned and was completely dismayed but in no way surprised when I read the introductory quote from the syllabus. Leo Simpson is completely

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Mailbag: continued

Earthquakes made for odd transmitter installations

Reading of the earthquake experiences of "The Serviceman" in the April 2012 issue took me back to the early 1960s when I worked for a couple of years in New Guinea as a P&T radio technician, specifically in Rabaul where earth tremors, or "guria" in the local dialect, were almost a daily occurrence. Major shakes took place at least monthly and severe shakes at least once a year.

Arriving in Rabaul at age 22 and completely green as far as what made the world turn, I was amazed to discover that our transmitters were not bolted to the floor and all the connecting cables were longer than necessary. The station Supervising Technician merely smiled at my disbelief and said I should wait for the next "guria". Later that week, it hit and I went into the transmitter room to find that the transmitters had all moved from their locations and needed to be pushed/kicked back into position.

If the transmitters had been bolted to the floor they would have suffered serious damage and may have even snapped the cables supplying power and antenna connections, as well as shaking the valves to pieces. Even with the loose mounting, there were occasional valve breakages, notably the mercury-vapour rectifiers which required a bit more of a clean-up as a result of the damage.

On one occasion during my tenure in Rabaul, where we were responsible for all the outstations hanging (in a wireless sense) off our transmissions and re-transmitting our signals, we had complaints that one of our services was always dropping off the air and was completely unreliable. Lucky me was sent to the island involved to sort out the problem which I was unable to identify, as it never happened whilst I was there (something about watched pots comes to mind).

Anyhow, after I gave up and went back, it failed again. My superior went out this time and came back a week later (that was a quick trip in those days) and gave me a hard time because he had found the problem and fixed it.

Eventually, I wheedled the answer out of him; minor earth tremors caused the transmitter to move slightly and the open-wire feeders would then short out across some metal roof support beams.

I can't say I didn't make any more blunders but we shan't discuss those that were not tremor-related. It had something to do with long wire antennae and coconut trees. But I digress.

Bob Forbes,
Forest Hill, Vic.

correct in his assessment; it is indeed drivel.

When I began teaching Physics, there were half a dozen core topics (motion, forces, mechanical interactions, electrical interactions, electromagnetism and waves). Students were also required to master three options (not ONE!) or electives as they were called back then. I taught atomic structure, nuclear physics and astronomy. The course was very mathematically based, with most exam questions involving calculations.

In the late 1990s, I attended several meetings to discuss the then up-coming new syllabus. They were a waste of time. Most of the teachers in attendance disagreed with many aspects of the planned format and were not backward in making that clear. The syllabus writers went ahead with their plans anyway! The meetings were simply a front to suggest that mainstream teachers had input.

I remember asking why the first topic in the new scheme was "The World Communicates" (basically wave motion) when at that point the concepts of velocity and motion itself

Not all earths are mains earths

The July 2012 issue has a "Soft Starter For Power Tools" article. This is fabulous for use from a personal safety aspect, work-place safety and in my case, limiting very high surges when using a solar power inverter supply. I do have one mains wiring concern with the circuit as published. The circuit diagram (on page 26 of the article) shows the supply Neutral coming via CON1 terminal 3 and down to the load current sense resistor and also shows the earth symbol connection at the bottom.

The wiring photo does not show this at all, ie, there is no second wire onto CON1 terminals 3 or 4. In other words, neither the mains supply, or the load neutral is being earthed within this box. Perhaps some clarification could be provided.

Joe Dennis,
Adelaide, SA.

Comment: what you are referring to is not mains earth and must not be connected to mains earth. It is more a circuit reference earth, to which the window comparator (IC1a & IC1b) and op amps IC1c & ICd are referred. The wiring diagram is correct.

had not been taught! The meetings were held at a club in Menai and I think many of us ended up exasperated in the bar!

I have also been a marker of HSC Physics for 15 years, and even achieved the position of Senior Marker (a position, by the way, which gave me the most satisfaction of my entire career in education). As a marker, I have obviously seen many student responses over the years but as Senior Marker I have also had to collect opinions and evaluations from markers under my supervision.

A common response was that it had been turned into an English exam; they were marking essays, rather than physics. To be fair, topics such as semiconductors were introduced in attempt to modernise the course but CRTs have all but vanished from everyday living since the syllabus was introduced.

The syllabus and textbooks include a glossary of "keywords" to point students in the right direction when writing their physics essays . . . "Identify", "Assess", "Explain", "Describe", etc. Over the years of marking, it became quite clear that ESL (English as a Second Language) students were having difficulty with the written responses, even though many showed an obvious understanding of the mathematical concepts of physics.

I have not had the opportunity to view the new physics syllabus so I must reserve comment. To be honest, we got used to the "new" syllabus over the years but I would like to see a return to the "nitty gritty" of the subject. Yes, there is a place for imagination in science (Einstein said so!) but let's face it, engineers don't build bridges by writing a story about it!

I really hope that the new scheme gets back to teaching and examining physics for the subject that it is – physics.

George Green,
Wollongong, NSW. SC

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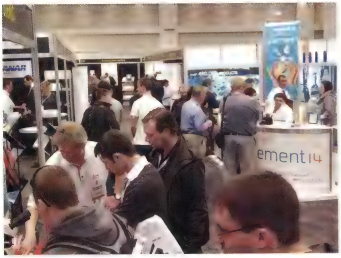

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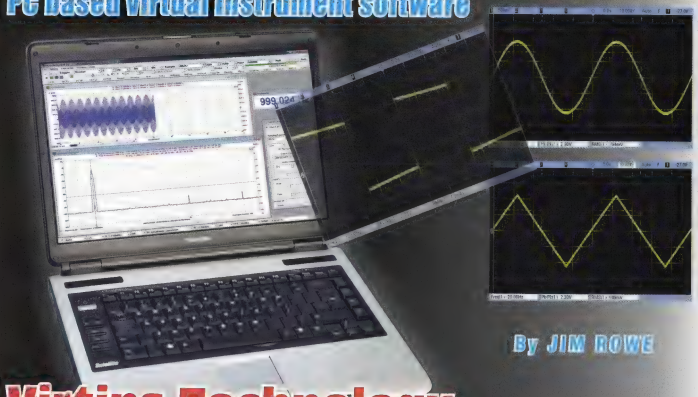

By JIM ROWE

Virtins Technology Multi-Instrument 3.2

Intrigued by the idea of using your PC as the engine for a suite of virtual audio test instruments? Here's a run-down on a powerful software package that will let you use it as a 2-channel audio scope combined with a powerful spectrum analyser, a 2-channel audio signal/function generator and an audio DMM which even includes a frequency counter!

BACK IN THE October 2011 issue of SILICON CHIP, we explained how to test common domestic audio gear using a good-quality sound card with your PC and running a virtual audio test instrument package like TrueAudio's TrueRTA.

While we found that TrueRTA has many worthwhile features, including the ability to make accurate frequency response and noise level plots, it did have a few limitations with regard to things like distortion and crosstalk measurements and plots.

Recently though, we became aware of another software package called Multi-Instrument 3.2, developed by a Singapore-based firm called Virtins Technology. Virtins has specialised in PC-based virtual instrument technology since it was founded in the early 1990s and in addition to the Multi-Instrument software package, it currently markets a range of virtual DSOs together with its own real-time audio analyser.

VMI 3.2 is the latest version of a software package first released in late 2004, for use with PC sound cards. It supports all Windows-compatible sound cards and interfaces and Virtins' own virtual instruments – plus many industrial ADC/DAC cards like the DAQmx series from National Instruments.

Like TrueRTA, an evaluation version of VMI 3.2 can be downloaded free from their website. In this case it's a fully-featured version which "expires" after 21 days unless you buy a licence from them online. There are three performance levels which may be purchased: "Lite" costing US$49.95, "Standard" costing US$99.95 and "Pro" costing US$199.95. There are also various add-on functions, like a Waterfall Plot/Spectrogram, Data Logger, LCR Meter and a Vibrometer, plus

an option which allows you to create, save and execute a series of Device Test Plans.

After downloading and trying out the evaluation version of Virtins Multi-Instrument 3.2 (VMI 3.2) for a week or two, we were motivated to develop the USB Virtual Instrument Interface featured elsewhere in this issue.

A virtual instrument suite

In Standard form, VMI 3.2 is a suite of the following virtual instruments:

- A 2-channel digital oscilloscope with a bandwidth from below 10Hz to 96kHz, depending on the capabilities for your sound card or ADC hardware. The sampling depth can be 8, 16 or 24 bits, again depending on your sound card. There are a range of triggering modes and display modes such as A and B, A + B, A - B, A x B and Lissajous (A against B). Each frame of data can be provided with a date/time stamp and the data can also be recorded continuously on the PC's hard disk.
- A 2-channel spectrum analyser with a selection of seven different display modes: amplitude/power spectrum, phase spectrum, auto correlation and cross correlation functions, coherence function, transfer function (Bode plot) and impulse response. The FFT window size can be selected from 16 different options, from 128 to 4,194,304 points, while there is a choice of no less than 55 different windowing functions including rectangular, triangular, Hanning, Hamming, Blackman, Gaussian, cosine, Poisson and so on.

The overlap between windows can also be set to any desired percentage, while there's a choice of many different display and scaling options for both the Y axis and the frequency axis. Parameters which can be measured using the spectrum analyser include bandwidth, crosstalk, THD, THD+N, SINAD, SNR and noise level (NL) in a specified frequency band. It's also possible to measure IMD (SMPTE/DIN, CCIF etc).

- A 2-channel digital signal generator, with a wide choice of waveforms and associated functions. Waveforms include sine, rectangle (with adjustable duty cycle), triangle, sawtooth and multi-tones like DTMF. There's also a choice of white or pink noise, maximal-length sequences with length adjustable between 127 and 16,777,215 samples, unit impulse and unit step, notes from the tempered musical scale and arbitrary waveforms (which may be stored on hard disk).

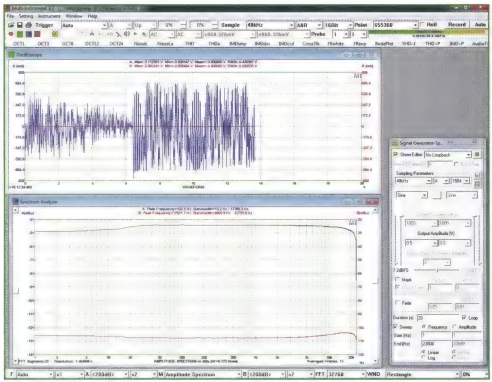

Fig.1: the main screen has four horizontal function bars along the top, with icons to activate the scope, spectrum analyser, DMM and generator. Here, the scope window is at upper left, with the analyser window below it. The smaller, narrower window at lower right is for the signal generator.

In addition, the generator can be set to provide any desired phase difference between the two output channels and it can mask their outputs in order to provide "burst" test signals. It can also provide sinewave signals sweeping either linearly or logarithmically between any two selected frequencies and at any desired speed.

It's also possible to set the exact output frequency to a value which minimises "spectral leakage" when you are using the spectrum analyser.

- An AC multimeter able to display RMS volts, dBV, dBu, dBrelative and dBA/B/C, plus cycle RMS and cycle mean. It can also function as a frequency counter, a tachometer (RPM), a straight counter, a duty cycle indicator and a frequency/voltage converter.

Calibration & compensation

VMI 3.2 also supports calibration of the input and output channels of your interface/sound card, so that absolute values in engineering units can be used for display, analysis or export. It is also able to account for external attenuator settings (such as the input switch settings in the Virtual Instrument Interface), as well as being able to compensate for hardware characteristics such as the frequency response deviations of the interface/sound card. Once measured, these can be saved as "reference curves" and loaded in whenever they are needed.

Zooming and scrolling in both the X and Y axes are supported in all graphs displayed by the scope and spectrum analyser, to allow inspection of fine details. In any case, VMI 3.2 provides a "cursor reader" for each graph, allowing you to determine the exact X and Y readings for any specific point just by clicking on it and holding the mouse button down. There are also two markers which can be set by double clicking, for comparison purposes.

Another nice feature of VMI 3.2 is a row of 16 "hot panel setting" buttons along the top of the screen. These are pre-configured to set up all the instrument panel controls and settings for specific tests. However you are free to reconfigure any or all of these buttons as you wish, for your own most-frequently performed tests. As part of the reconfiguring, you are even able to change the legend on the button being "reprogrammed".

It's also quite easy to save any de-

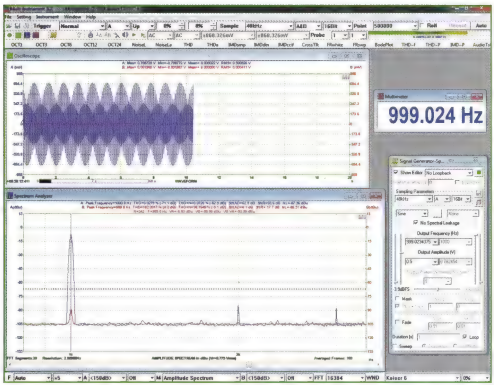

Fig.2: the DMM function is displayed in its own window (shown here at upper right) and this window can be adjusted for size and position on the screen. In this screen grab, it is shown displaying the generator frequency in use.

sired screen layout and combination of instrument settings as the default "skin" for VMI 3.2 when you start it up each time. In short, it offers a high degree of customisation.

All data collected by the VMI 3.2 oscilloscope or spectrum analyser can be saved, either as a wave file or a text file. All graphs can also be exported as bitmap (.BMP) files or printed out directly. And waveform files saved in either .WAV or .TXT form can be imported into the Generator to generate that waveform again.

System requirements

VMI 3.2 is compatible with all versions of Windows from Windows 95 to Windows 7, either 32-bit or 64-bit. Virtins suggest that for optimum results, your monitor should have a horizontal resolution of at least 1024 pixels.

As you've no doubt gathered from the above, VMI 3.2 has an almost bewildering array of functions and facilities. Fortunately, there is a 283-page user manual which can be downloaded in PDF format. And there are tutorial articles on FFT spectrum analysis, including one on FFT basics and another comparing the umpteen different FFT windowing functions.

Trying it out

I installed a copy of VMI 3.2 Standard on an Acer AX1800 desktop PC running Windows 7 Home Premium (64-bit). It installed without a hitch and very soon I was looking at a main screen much like that shown in Fig.1.

It has four horizontal function bars along the top, starting with the usual Menu bar (File – Setting – Instrument – etc). There's a scope triggering and sampling parameter toolbar for the scope and spectrum analyser, followed by an "Instrument and Miscellaneous" toolbar with icons to activate the scope, spectrum analyser, DMM and generator – plus settings to adjust scope input sensitivity, take into account whether there's an external input attenuator and so on.

There's also a coloured bargraph on the righthand end of this bar, showing you the amplitude of any input signals at the scope/analyser inputs. Finally, there's the row of "hot panel" toolbar buttons, shown here with their pre-programmed default functions.

You activate the various instruments by clicking on their icons, with each instrument opening in its own window in the main part of the screen. In the case of the scope and analyser windows, you can adjust their size and position in the usual way.

In Fig.1, you can see the scope window at upper left, with the analyser window below it. The smaller and narrower window at lower right is for the generator, which is deliberately designed to be as compact as possible so that most of the screen is free for you to make the other two windows as large as possible.

Unlike the scope and analyser windows, the generator window can't be continuously adjusted in terms of size but it can be truncated or "shrunk" into just the upper 20% or so (by unticking the "Show Editor" button) once you have set up the generator. In any case, it automatically varies in terms of screen height according to the operating mode selected.

For example, if you don't activate sweeping, the window contracts up from the bottom to remove the bottom 20% or so.

The DMM

If you activate the DMM, it is displayed in its own window, which can be adjusted in size and position. You can see it at upper right in Fig.2, displaying the generator frequency in use. Note that in this case, the generator has been set to a frequency very close to 1kHz but not exactly so. This was done by selecting the "No Spectral Leakage" option in the generator window, to change the frequency to that nearest 1kHz which would give the "sharpest" FFT resolution in the analyser.

Because there are so many display options for each of the instruments in the VMI 3.2 package, providing for

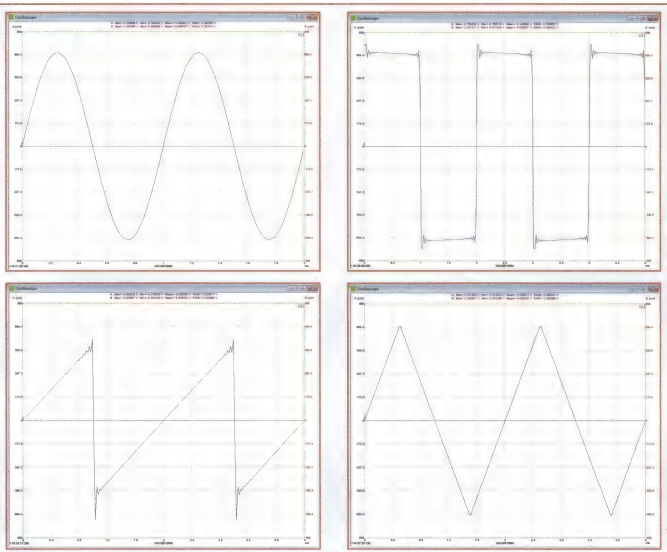

Fig.3-6: these four screen grabs show a 1kHz sinewave, a 500Hz square-wave, a 500Hz sawtooth and a 500Hz triangular wave, as generated by the VMI 3.2 software and displayed in the "scope" window on a PC.

their setting could easily take up a lot of screen space and encroach into the important data display area. But the software designers have been clever, because each of the main instrument display windows (scope, spectrum analyser and DMM) has its own "View Parameter Toolbar", which only appears along the bottom of the screen when that instrument's display window has been selected.

So if you select the scope window, its parameter toolbar appears at the bottom; select the analyser window instead and its parameter toolbar appears – that's the one you can see along the bottom of Fig.1. Similarly, if you select the DMM window, its own parameter toolbar is shown.

This makes it easy to adjust the function and display parameters for each instrument, without sacrificing a lot of screen area. As you can see, the spectrum analyser's parameter toolbar allows you to adjust many of the important parameters, most of them via pop-up menus (which again minimises screen space).

Before we leave Fig.1, I should perhaps explain the displays that you can see in the three instrument windows. In this case, VMI 3.2 had been set up to do an overall frequency response and inter-channel crosstalk test of my new USB Virtual Instrument Interface, with a short cable looping the channel A generator output back to the channel A input and the channel B input terminated in a shielded 50Ω resistor.

As you can see, the generator was set to produce sinewaves of 0.5V RMS, sweeping linearly from 1Hz to 23.5kHz over a period of 20 seconds. Up at the top you can see that the scope and analyser were set to sample both input channels (A&B) at 48kHz and 16 bits, for a total record length of 655,360 points – which, if you work it out, takes 13.6 seconds (655,360 ÷ 48,000).

Down in the bottom analyser toolbar, you can see that an FFT size of 32,768 had been selected, resulting in a total of 20 FFT segments (655,350 ÷ 32,768) and an analyser frequency resolution of 1.46484Hz (48,000 ÷ 32,768). A rectangular window was also selected, with no overlap between windows.

Aliasing effects

I should comment on the strange display in the upper scope window; for this kind of test, it is badly affected by aliasing because of the way the signal is sweeping between 1Hz and 22.3kHz over the sweep period. But the spectrum analyser display below

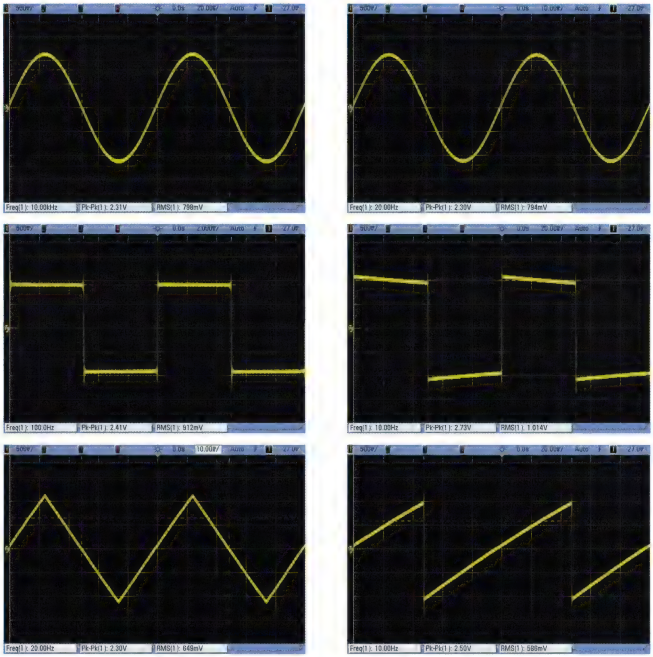

Fig.7-12: these scope grabs show sinewaves at 10kHz & 20Hz; square waves at 100Hz & 10Hz; a triangle wave at 20Hz; and a sawtooth at 10Hz. The overshoot visible on the square wave signals is probably due to the characteristics of the anti-aliasing LP filter in the USB Virtual Test Instrument Interface output channels while the droop visible at the top and bottom of the 10Hz square wave is due to the low frequency roll-off in the same output channels.

it shows the real results of the test – the overall frequency response of the Interface's channel A in blue near the top and the crosstalk into the channel B input in red near the bottom.

It's not easy to read off the exact values of either curve from the display as shown, although if you use VMI 3.2's cursor reader facility you can get it to show the exact value of both curves numerically, just at the top of the graph itself. In addition, the analyser parameter toolbar at the bottom allows you to zoom into the graph in terms of frequency and also in terms of amplitude – so you can expand either or both curves as much as you need, shifting along to any frequency range and shifting each curve up or down so you can inspect them visually in minute detail. Not bad, eh?

There's no problem about exporting or printing any of the analyser displays at any time, either. All you have to do is pause the analyser and click the relevant buttons.

Other capabilities

Now let's look at Fig.2 again, as this illustrates a few more aspects of VMI 3.2's capabilities (in addition to the DMM window).

When this screen grab (ie, Fig.2) was taken, I had been using VMI 3.2 to measure the overall distortion and noise performance of the new USB

Test Instrument Interface's channel A output and input at 1kHz. As before, these were linked via a short cable and the channel B input terminated with a 50Ω resistor.

The generator had been set to produce a 999.024Hz sinewave of 0.5V RMS and the analyser to take 500,000 samples per record. The FFT size had been set to 16,384, with a Kaiser6 window function. This gave 30 FFT segments per record and a frequency resolution of 2.92969Hz.

Again you shouldn't take too much notice of the upper scope window, because it's showing the severely aliased display of 500,000 samples of a 1kHz waveform taken over 10.4 seconds. But there's quite a deal of information to be gleaned from the lower analyser window, because just before the grab was taken I had zoomed the horizontal frequency axis by five times and then moved along to show just the range between 800Hz and 3.5kHz.

As a result, you can clearly see the fundamental peak of the 1kHz generator signal, together with the second and third harmonic peaks generated by distortion in the USB Test Instrument Interface's channel A output and input circuitry (blue graph). You can also see the crosstalk into the channel B input circuitry (red graph).

Above the graphs, the analyser displays the calculated THD (0.0279%) and THD+N (0.0720%) figures for channel A (blue text), along with the SINAD, SNR and NL. It also does these calculations for channel B but these are not important because they represent crosstalk distortion.

Since I had placed the reading cursor at the 1kHz peaks (vertical red line on the graphs), the analyser has also calculated the amplitude of the fundamental peaks in both channels and displayed them in dBu on the third line from the top. The channel A peak is -8.00dBu, while the channel B peak is -88.99dBu. You don't have to subtract one from the other to work out the crosstalk at 1kHz either, because the analyser does that as well and displays it at the end of the line (-80.99dB).

Generator waveforms

The remaining screen grabs from VMI 3.2 and the accompanying scope grabs (Figs.7-12) indicate the variety of waveforms that can be delivered by VMI 3.2's signal generator.

For example, Figs.3-6 show a 1kHz sinewave, a 500Hz square-wave, a 500Hz sawtooth and a 500Hz triangular wave, as displayed on VMI 3.2's own scope. Figs.7-12 are a series of scope grabs showing sinewaves at 10kHz and 20Hz; square waves at 100Hz and 10Hz; a triangle wave at 20Hz; and a sawtooth at 10Hz.

The overshoot visible on the square wave signals is probably due to the characteristics of the anti-aliasing LP filter in the USB Virtual Test Instrument Interface output channel, while the droop visible on the top and bottom of the 10Hz square wave is due to low-frequency roll-off in the same output channels.

There's no doubt that Virtins Multi Instrument 3.2 is capable of delivering professional-grade results, especially if you were to use it with the highest quality ADC and DAC interface hardware. It's extremely flexible, yet at the same time quite user friendly.

Overall, Virtins VMI 3.2 represents excellent value for money – especially the Standard version at its current price of only US$99.95. For further information, see **virtins.com** SC

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One number rings multiple phones

Pt.1: By GEOFF GRAHAM

The COLOUR MAXIMITE

A PIC32-Based Microcomputer With Colour Output & Stereo Audio

The original Maximite microcomputer (March-May 2011) has been a huge hit with readers and thousands are now in use all over the world, from Australia to Russia. So how do you improve on such a big hit? How about by adding eight vibrant colours and a stereo music synthesiser for a start? The result is stunning and it takes the Maximite to a whole new level.

THE MAXIMITE is a small, self-contained computer that is ideal for experimenting, learning programming and for use as an embedded controller. It uses a standard VGA monitor for display, a standard PS2 keyboard for input and an SD card for storage.

It includes its own operating system and BASIC programming language (called MMBasic), so you do not need to tether it to a larger computer. It also starts up instantly, so you can just plug it in and immediately get going by entering commands and a program.

The new Colour Maximite has 40 input/output (I/O) lines which can be independently configured as analog inputs, digital inputs or digital outputs. You can measure voltages and frequencies, detect switch closures, and so on, and get it to respond by turning on lights, closing relays, etc – all under control of your BASIC program.

Perhaps the most amazing thing about the Colour Maximite is that, like its predecessor, everything (VGA, USB, colour, music, etc) is generated by a single chip that costs less than $10.

For people who are familiar with the original Maximite, the Colour Maximite has a similar component count so the cost of building the colour version should be about the same. It's also reasonably easy to build; just an hour or two is all that's needed.

Suggested uses

What would you want to use the Colour Maximite for? Well, for a start, you could simply use it as a small computer that will remind you of the early days of personal computing, when computers were less complicated and much easier to use. The Colour Maximite allows you test your programming skills and have fun creating small programs that can do anything from

Features & Specifications

- Self-contained high-performance microcomputer.
- Microchip 32-bit processor running at 80MHz with 512KB flash memory and 128KB RAM.
- **Colour VGA output, 480 x 432 pixels with eight colours (black, red, green, blue, cyan, yellow, purple and white).**
- Standard PS/2-style keyboard input.
- **Stereo audio synthesiser for music and sound effects.**
- **Battery backed real-time clock (optional).**
- 20 external I/O lines which can be configured as analog inputs, digital inputs/outputs, frequency measurement, etc.
- **Arduino compatible connector with an additional 20 I/O lines that are independent of the original 20 I/Os.**
- SD card support – up to 32GB for storing programs and files.
- USB port for connecting to a personal computer (Windows, Mac or Linux) as a terminal or for file transfer.
- Extensive communications protocols including serial, I²C, SPI and 1-wire.
- **2-channel audio/analog/PWM analog output.**
- Graphic capability includes selectable fonts, user designed fonts, drawing lines, circles, squares and control over any pixel with any colour.
- **Special commands for animated games. BLIT will copy a block of the video screen at high speed and SPRITE will create animated sprites that can be moved on the screen without disturbing the background.**
- Firmware upgrades via USB.
- Full-featured BASIC interpreter and operating system.
- Instant on (ready for you to type in and test programs).
- Powered from USB, 9V plugpack or battery.

Note: new features for the Colour Maximite shown in bold.

discovering prime numbers to hunting the Wumpus. It will take you back to the days when the Tandy TRS-80 and Commodore 64 were hi-tech.

A second use for the Colour Maximite is in controlling the outside world. As stated, with its 40 I/O pins, you can use the Colour Maximite as an embedded controller to monitor voltages and signals and then respond by operating motors, turning on lights or driving an LCD. The Arduino connector makes it easy to add your own customised circuits or relay drivers to interface to the real world.

There are already many Maximites out there that are used by readers to monitor GPS receivers, control windmill power systems and many other tasks both complex and simple. With double the number of I/O pins compared to its predecessor, the Colour Maximite can be used for even more complex projects.

The Colour Maximite also supports a wide range of communications protocols – serial, I²C, SPI and 1-wire. These are mostly used for communicating between semiconductor chips so, using the Colour Maximite, you can easily measure temperatures, log data or interface with a test instrument.

The Colour Maximite should also encourage another group of readers who enjoy writing and playing animated games. Colour is especially useful for games and the Colour Maximite has a special high-speed colour mode designed for that use. Version 4.0 of MMBasic also has some special commands (BLIT and SPRITE) that are designed to move video images around the screen – just what you need for an animated game.

Colour, colour

The technique for producing colour was developed by Dr Kilian Singer, a Maximite fan at the University of Mainz in Germany. He built a prototype Maximite on a breadboard, started experimenting with it . . . and came up with colour.

The technique he used is deceptively simple. The monochrome Maximite generates its image by tying the three colour inputs on the monitor together and drives them with a single SPI channel (we will delve more into that technique later). To generate colour, we just use three separate SPI outputs to independently drive the three colour inputs to the monitor.

Sounds simple – so why didn't we do that in the first place and give the original Maximite colour?

The answer is that the original Maximite did not have the speed or memory capacity. But with successive releases of the Maximite firmware, we have optimised its speed and memory usage to the point where this technique is now viable.

It's not a completely free lunch though. Generating colour uses more of the processor's time so, with eight colours, programs will run about 25% slower and there's less free memory than when generating a single colour.

Most readers won't notice this so it is a worthwhile trade-off. And in any

The Colour Maximite interfaces to a VGA monitor and a standard PS/2 keyboard. You can see how small the unit is compared to these external parts. The monitor is shown here displaying the start-up screen, with MMBasic loaded and ready to run programs.

case, you can easily switch into monochrome mode within your programs and get the speed and memory of the monochrome version if required.

New PIC32 chip

One of the issues with generating colour is that it requires three separate SPI outputs. We also need an additional SPI output for the SD card, so that's four in total. The 64-pin PIC32 chip used in the original Maximite only has three SPI devices so, for the Colour Maximite, we needed to move to the 100-pin variant which has four SPI outputs.

Most 100-pin chips have fine leads with a very small gap between them and that makes it extremely hard to hand solder the chip to a PCB. That's the reason we didn't use the 100-pin chip in the original Maximite design (the cost is similar).

Fortunately, Microchip now produce a 100-pin version of the PIC32 with the same pin spacing as the 64-pin chip. The chip's package is bigger (14 x 14mm) but we have plenty of space on the PCB so that's not a problem.

Arduino connector

With the 100-pin chip, you also get a lot more I/O pins so we decided to put them to good use.

First, we decided to add an Arduino-compatible connector. This provides an additional 20 I/O pins that can be controlled from within MMBasic and are independent of the standard 20 Maximite-compatible I/O pins on the back panel.

The Arduino connector is mounted on the top of the PCB and is primarily intended for use with Arduino-compatible prototyping boards which can be purchased cheaply from many retailers and on the internet. These boards are called "shields" in "Arduino speak" and can be stacked on top of each other.

There are many Arduino shields available (we covered the Arduino world in the January 2012 issue) but you need to be aware that many require a specialised driver to be included in your program (which must be written in the C language).

For this reason, we recommend that the Colour Maximite's Arduino connector be used with simple prototyping boards, relay boards and others that do not require special software to drive them and can work with 3.3V. There are plenty of these out there and they are very cheap.

With the Arduino-compatible connector, you can construct special circuits on a prototyping board and permanently add them to your Colour Maximite. This feature can be used for adding signal amplifiers, relay drivers and many other simple applications.

Stereo audio output

Another new feature in the Colour Maximite is a stereo audio output. This can be used to play music, generate tones and create program-controlled analog voltages.

The *PLAYMOD* command will start a music synthesiser which is built into the latest version of MMBasic. This command will read a sequence of instructions from a file in the MOD format and generate high-quality stereo music which will play in the background.

You can use this feature to liven up games, add sound effects to your programs and provide some interesting warning signals.

The *TONE* command also uses the stereo audio output and will generate a sinewave at the output with selectable frequencies for the left and right channels. This is intended for generating attention-catching sounds but because the frequency is very accurate, it can be also be used in many other applications, eg, creating DTMF tones or testing the frequency response of loudspeakers.

Another new command in MMBasic is the *PWM* command which uses the audio output connector to deliver analog voltage signals. There are two outputs and these can be set to any voltage from 0-3.3V under program control. They could be used to drive a voltage-controlled power supply, a motor controller or anything else that needs an analog voltage input.

Battery-backed clock

Yet another new feature in the Colour Maximite is the provision of a

battery-backed clock. This runs independently of the PIC32 and will keep the correct time when you remove power from the computer.

Not all readers need this feature, so we have made it optional – refer to the accompanying panel "Adding The Battery-Backed Clock Option" for details.

BASIC language

A great feature of the Maximite is that it comes complete with its own BASIC programming language, called MMBasic.

This language is generally compatible with Microsoft BASIC and allows you to type your program directly into the Maximite. You can then test and run your program while getting instant feedback. This is a full-featured implementation of the BASIC language and it supports floating point, arrays with multiple dimensions, long variable names and many other powerful features.

A key feature of MMBasic is its support for the SD-card interface in the Colour Maximite. You can store programs and data on the card and because the Colour Maximite uses the standard FAT16 or FAT32 file system, you can pop the card into your desktop computer to access and edit data created by your programs.

The most important benefit of BASIC is that it is very easy to learn and use. This makes it ideal for people who would like an easy introduction to programming and want to just play around without being forced into a complicated programming environment.

Since its introduction with the original Maximite, MMBasic has been continuously improved. It now includes a full-screen editor and your programs do not need to use line numbers. You can also use modern programming structures like subroutines and functions with parameter lists to make your programs more readable and easier to maintain.

With the Colour Maximite, we have introduced version 4.0 of MMBasic. The most obvious addition to this version is support for colour and there's also support for a stereo synthesiser.

Other additions include two commands especially suited for programming games. These commands are (1) *BLIT* which will rapidly copy an area of the video output to another location on the screen; and (2) *SPRITE* which enables you to create animated graphics that can move across the screen without disturbing the underlying graphics.

Version 4.0 of MMBasic is not exclusive to the Colour Maximite. There is also a version for the original Maximite and it is worth updating to it if you are running an earlier version. Of

Colour Maximite: Parts List

1 PCB, code 07109121, 130 x 102mm
1 plastic case, 140 x 110 x 35mm (Jaycar HB-5970, Altronics H0472, Element14 1526699)
1 SD memory card connector (Hirose DM1A, Element14 1764372, 4UCON 19607)
1 USB Type-B socket, PCB-mount (Jaycar PS-0920, Altronics P1307, Element14 1696537)
1 DE-15 (or HD-15) high-density 15-pin female D connector (AMP 1-1734530-1, MULTICOMP SPC15430, Element14 1557991 or 1564252)
1 8MHz crystal (HC-49 low profile)
1 IDC 26-pin boxed header, 90° PCB-mount
1 6-pin mini DIN female connector socket, PCB-mount
1 2.1mm DC power socket, PCB-mount
1 3.5mm stereo phono socket, panel-mount
1 micro-tactile pushbutton switch
2 3-pin SIL headers, 0.1-inch (male)
2 shorting blocks
1 3-pin polarised header plug, 0.1-inch, PCB-mount
1 3-pin polarised header socket
2 8-pin header sockets (Jaycar HM3207)
2 6-pin header sockets (Jaycar HM3207)
1 type 6073 mini TO-220 heatsink (Jaycar HH8502, Altronics H0630)
4 No.4 x 9mm self-tapping screws (to secure PCB)
1 M3 x 6mm machine screw
1 M3 nut
1 M3 star washer
1 100mm-length 3-way ribbon cable

Semiconductors

1 PIC32MX695F512L-80I/PF or PIC32MX795F512L-80I/PF microcontroller (IC1) (Microchip Direct, Element14 1778489 or 1778491)
1 7805 5V voltage regulator, TO-220 package (REG1)
1 TC1262-3.3VAB 3.3V voltage regulator, T0-220 package (REG2) (Microchip Direct, Element14 1852182)
1 1N4004 silicon diode (D1)
2 1N5819 Schottky diodes (D2-D3)
3 1N4148 silicon diodes (D4-D6)
1 green 3mm LED (LED1)
1 orange 3mm LED (LED2)

Capacitors

1 10µF 6.3V ceramic, SMD 0805 package (Element14 1844286)
2 10µF 25V tantalum
1 330nF MKT
7 100nF monolithic ceramic
2 47nF MKT or polyester
2 22pF ceramic

Resistors (0.25W 5%)

1 10kΩ	2 47Ω
2 4.7kΩ	1 10Ω
5 1kΩ	1 2.2Ω
3 120Ω	

Parts For Battery-Backed Clock

1 coin cell holder (see **futurlec.com**, Element14 2064715)
1 CR2032 lithium cell (coin type) or 1 x CR2032 PCB-mount lithium cell (Jaycar CR-2032VC, Element14 189267001)
1 32.768kHz watch crystal

Semiconductors

1 DS1307 real time clock (RTC), 8-pin PDIP package (see **futurlec.com**, Element14 1188042)

Capacitors

1 100nF ceramic or MKT

Resistors (0.25W, 5%)

2 10kΩ

Note: a PCB (with screen-printing & solder mask) and a programmed PIC32 micro are available from the Silicon Chip Partshop.

Left: inside the Colour Maximite's case. There's not a lot to it as all the "smarts" are inside the 100-pin PIC32 chip in the centre of the PCB. The unit has a USB interface and supports SD cards with capacities up to 32GB for storing programs and files.

course, you will not get colour output but the other features will all work, including the music synthesiser (with mono output).

How it works

Take a look now at Fig.1 which shows the complete circuit diagram of the Colour Maximite. It's really quite simple and basically consists of a PIC32 chip with a lot of connectors attached.

The most complicated part of the Colour Maximite is the VGA driver and that only uses one resistor and one diode for each colour.

VGA colour video consists of separate red, green and blue signals. If you mix red and blue you get purple, while mixing red and green gives yellow and so on. If you count black and white as colours, this means that we can get eight colours just by switching the red, green and blue signals either fully on or fully off.

In the Colour Maximite, each colour uses an identical scheme to generate the video so we'll just look at one colour channel to see how it's done. Fig.2 shows the basic details.

Within MMBasic, the video data is stored as a bitmap in general RAM. This means that when something is to be displayed, the firmware must convert it into individual pixels before writing these to the video buffer. This applies regardless as to whether it is a character or a graphic symbol.

The process of turning this bitmap into a video stream starts with the horizontal sync pulse. This is created by a timer within the PIC32 that is configured to generate a 3.813µs horizontal sync pulse every 31.778µs (about 31kHz). Once configured, this timer runs continuously without further intervention.

An interrupt is triggered on the leading edge of each horizontal sync pulse, which causes the processor to stop whatever it is doing at the time and run a special section of its program. In this routine, the processor calculates the memory address of the next line of pixels and instructs the DMA (Direct Memory Access) system to copy that part of memory to the SPI (Serial Peripheral Interface).

The SPI is a circuit in the PIC32 that takes a byte of data and outputs it one bit at a time with specific timing. It is this stream of 1s and 0s that forms the video signal. A logic 1 (or high voltage) is an illuminated pixel while a logic 0 is a pixel that is off. The resistor and diode at the output clamp the video signal to 0.7V to conform to the VGA standard.

As the scan line progresses across the screen, the DMA sequentially reads the data in memory and pushes it to the SPI device which in turn sends the data bit by bit to its output. The beauty of this scheme is that, other than setting up the DMA and SPI at the beginning of the scan line, the processor is free to undertake other duties (like running your BASIC program) while the video is generated in the background.

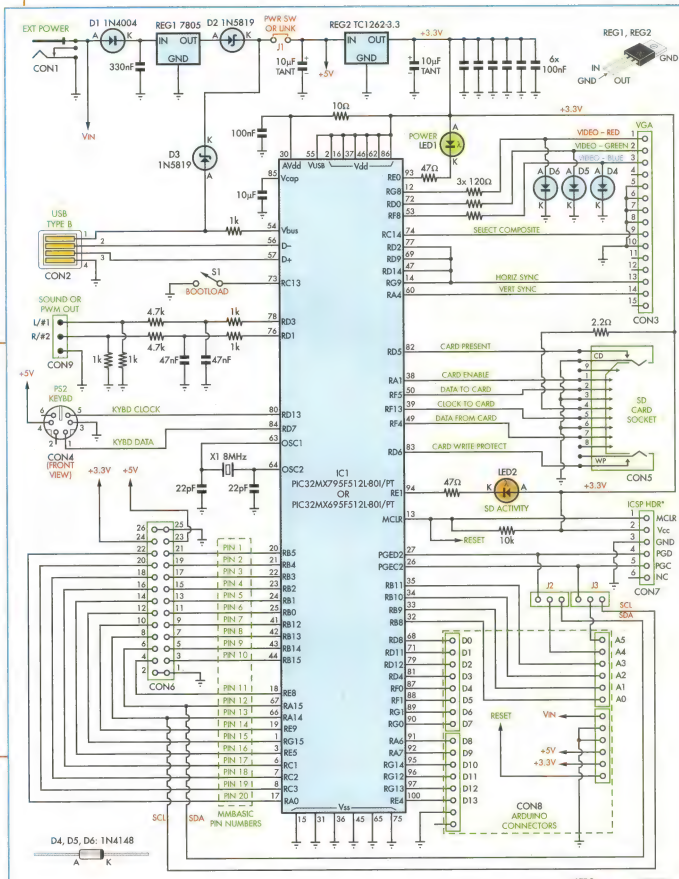
Framing input

There's just one problem with this scheme. Because of the way the CPU works, you cannot precisely guarantee when it will start the video stream – it may be a little earlier or later than the previous scan line. While these differences are small (only a few tens of nanoseconds), they will show up as a jitter in the video output.

To eliminate this, we take the horizontal sync pulse generated by the timer and feed it back to the SPI as a "framing input". This can be seen in Fig.1 where pins 69, 47 & 14 are the framing inputs (one for each colour) and 77 is the horizontal sync output. Framing is a special feature of the PIC32's SPI and it forces the SPI to wait for the trailing edge of the sync pulse before starting the data stream.

The benefit of this feature is that the video stream will always be precisely

Fig.1 (right): the circuit is based on a PIC32 microcontroller. It manages everything, including the colour VGA, keyboard, SD card and I/O and it does this while running a BASIC program at high speed. Regulators REG1 & REG2 respectively produce a +5V rail for the keyboard and a +3.3V rail to power the PIC32 and the SD card. Note: this diagram does not include the battery-backed clock option which is shown separately in Fig.3.



COLOUR MAXIMITE COMPUTER

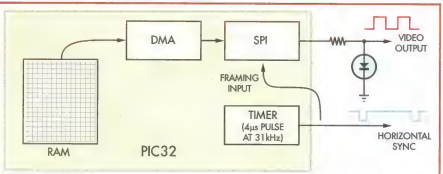


Fig.2: the video is generated entirely inside the PIC32 chip. It starts with the MMBasic software which converts the data to a bitmap and then writes that bitmap to a portion of memory reserved as the video buffer. This buffer is then streamed by the DMA controller to the SPI output which in turn feeds it to the video output one bit at a time, with each bit representing one pixel.

synchronised with the sync pulse – and therefore will display without any jitter.

As far as we know, the PIC32 is the only microcontroller that has the resources needed for the Colour Maximite and has framed SPI. That is why we used the PIC32 and not some other processor (there are many similar processors on offer).

The video bits are clocked out at a frequency of 20MHz. This means that the DMA circuit must read the video buffer and pump the data to the SPI at that same frequency. And because there are three colours with three DMA/SPI channels running in parallel, the total data rate is 60 million bits per second.

Fortunately, the PIC32 has a sophisticated system to connect memory and peripherals (called the switching matrix) but the overhead in handling this volume of data is one of the reasons why the Colour Maximite runs a little slower when in the 8-colour mode compared to the monochrome mode.

Power supply

The Colour Maximite will happily run on a DC supply from 7-16V (9V recommended) with a current drain of about 160mA. It will also run on 5V via the USB connector.

When running from a 7-16V rail, a simple 3-terminal regulator (REG1) is used to derive the 5V supply. Because the power can also come via the USB connector, diodes are used to select the source for the rest of the computer.

A second 3-terminal regulator (REG2), a Microchip TC1262, is used to drop the 5V rail to 3.3V for the PIC32 micro and the SD card. While this regulator looks like any other 3-terminal regulator, this particular type was chosen for two key characteristics.

First, it has a low drop-out voltage, which is essential because the USB supply can be as low as 4.5V and this combined with the 0.3V drop across the diode gives the regulator less than 0.9V to work with. Second, it has a very accurate output voltage. The specifications state ±0.5% but on the samples we checked, the output was within 0.05% of 3.3V.

This is important because this voltage is used as the reference when the PIC32 measures a voltage on one of its input pins. The more accurate the supply voltage, the more accurate the reading will be.

There is a third regulator which you cannot see. This is internal to the PIC32 and provides 1.8V for the MIPS CPU which is at the core of the PIC32 chip. This voltage appears at pin 85 of the PIC32, where a 10µF ceramic capacitor is used to suppress noise and stabilise the regulator. It is difficult to find a through-hole component of this value so a surface-mount capacitor is used in this location.

There are also quite a few 100nF capacitors sprinkled around the PCB and connected across the 3.3V supply rail. They are there to suppress the switching noise generated by the PIC32 as it races through your program.

External I/O

Many Arduino systems make the I^2C signals available on connector pins A4 & A5. We have therefore provided two jumpers (J2 & J3) so that you can select between the normal I/O function for these pins (A4 & A5) or the I^2C signals (SCL and SCA). Note that these I^2C signals are also on external I/O pins 12 & 13 on the back panel, so effectively these jumpers join these I/O pins together when in the I^2C position.

The keyboard, SD card, USB and external I/O connectors all connect direct to the PIC32. Care is required when using the external I/O pins, as there is no special protection for these inputs. The PIC32 is a tough little chip but it can still be damaged by a high-voltage static spark or a voltage outside its operating range. As a result, it's a good idea to always touch a ground point before handling the I/O pins. Similarly, always double-check your connections before applying power.

The sound output circuit shown in Fig.1 is intended for driving an audio amplifier but you can easily modify the output to drive headphones or even an efficient speaker. The audio generated by MMBasic is output as a pulse width

This rear view shows (from left to right) the VGA socket, the DC power socket, the multi-way I/O connector, the keyboard socket and the audio and USB sockets. Power comes from either a USB port or a 9V plugpack (or battery).

Adding The Battery-Backed Clock Option

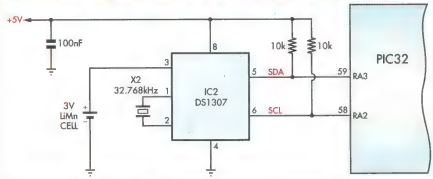


Fig.3: the add-on circuit for the battery-backed clock option. It's based on a Maxim DS1307 real-time clock (RTC) chip and a 32.768kHz watch crystal.

ONE OF THE most popular requests for the original Maximite was the addition of a battery-backed real-time clock.

The Maximite already had an accurate method of keeping time but the problem was that the time was lost when ever the power was turned off. This meant that it had to be reset (if you needed the correct time) each time the Maximite was powered up.

For most people, this wasn't an issue. If you are writing a game or calculating prime numbers, the time is irrelevant. However, for some uses (eg, data logging), being able to keep the correct time is important.

For this reason, we have made space on the PCB for a battery-backed clock. When you add these extra clock components, MMBasic will automatically recognise the presence of the clock and retrieve the time from it each time the system boots. Conversely, if you leave the components out, MMBasic will carry on as before and use the PIC's internal clock which is reset to zero on power up.

Circuit details

The circuit shown in Fig.3 is simple enough. It's based on a Maxim DS1307 real-time clock (IC2) and this uses a 32.768kHz watch crystal to accurately track the time and the date, including adjustments for leap years.

The DS1307 communicates via the I²C protocol with the PIC32. MMBasic uses this to interrogate the chip on power-up and then uses the PIC's own crystal-locked clock to keep track of time from then on. The reason for this is that it's much faster to retrieve the time from internal registers rather than request it over the relatively slow I²C bus.

A great feature of the DS1307 is that it monitors its supply voltage on pin 8 and automatically switches to battery power when the supply voltage drops below a threshold. At the same time, it disables the I²C bus to prevent random noise from being interpreted as a command to change the time.

We've specified a CR2032 lithium cell in this circuit because it's cheap and readily available but it's really overkill. The DS1307 consumes about 0.25μA when running off the cell and given the 140mAh capacity of the CR2032, this translates into a cell life of about 64 years! This means that the limiting factor will be the shelf-life of the CR2032 which is more than 10 years.

Moon Lander

Check out this video and see what Fabrice Muller (one of our beta testers in France) has done with with the Colour Maximite:

http://youtu.be/knq5vX65Xy4

Everything, including the sound, is generated by the Colour Maximite!

modulated (PWM) signal on pin 76 of the PIC32 for the right channel and pin 78 for the left.

PWM can be used to generate an analog output from a digital source. It uses a high-frequency sequence of pulses (about 100kHz) and MMBasic can modulate the output by varying the duty cycle. When the signal is averaged (using a low-pass filter), we end up with an analog voltage that's controlled by your BASIC program.

So before we feed the signal to an amplifier, we need a low-pass filter. This is done using a 1kΩ resistor and 47nF capacitor in each channel, which together form a simple low-pass filter with a -3dB point of about 4kHz.

Following this, an attenuator consisting of 4.7kΩ and 1kΩ resistors reduces the output to about 0.5V p-p (peak-to-peak). This attenuator also isolates the filter from variations in the load presented by the amplifier.

An alternative is to drive a set of earphones. The low-pass filter isn't required in this case, as the headphone coils will do the averaging for you. This means that you can omit the capacitor in the low-pass filter and the attenuator. However, to avoid damaging your hearing, the 1kΩ resistor should be increased to 4.7kΩ or higher.

If you can live with a low volume, you can even drive an efficient speaker direct. In this configuration, you need to reduce the 1kΩ resistor to 22Ω, replace the 4.7kΩ resistor with a link and leave out the 47nF capacitor. The sound level will depend on the efficiency of the speaker but don't expect it to be loud.

Analog outputs

As previously stated, the sound output can also be used to generate two independent analog voltage outputs. MMBasic has a command specifically for this (the *PWM* command) and when you use the outputs in this mode, you should not use any of the audio commands.

In this case, you probably want a much lower filter frequency to give a smoother output so you should replace the values shown on the schematic with something more suited to your application. This can be easily calculated using the formula:

$$RC = 1 \div 2\pi F$$

where R and C are the values in the low-pass filter and "F" is the roll-off frequency.

Typical values would be 4.7kΩ and 330nF, which would give a fast enough response for you to quickly change the output while eliminating most of the PWM switching.

If you want to use these outputs to generate a PWM square wave rather than an analog voltage, you can use the same method as described above for connecting a speaker; ie, use a 22Ω resistor and a wire link.

Next month: construction!

Well, that's all we have space for this month. In Pt.2, we will describe how to put the Colour Maximite together and give you an introduction to programming in colour. **SC**

Does that @!#$%*~ dog drive you Barking Mad?

Don't get mad – get even with our new

BARKING DOG BLASTER

By JOHN CLARKE

Let's face it: there are few things more annoying than a dog which won't shut up. But now you can fight back: every time it starts to bark, give it a blast of ultrasonic screaming. It won't hurt the dog but it should quickly learn that barking can have unpleasant results!

Barking dogs can make life a misery, especially at night when you are trying to get to sleep. Or maybe you are not trying to sleep; you just want some peace and quiet! Of all the tensions that can arise from living in suburbia, barking dogs must be right there near the top of the list. If you have this problem, you have our sympathy.

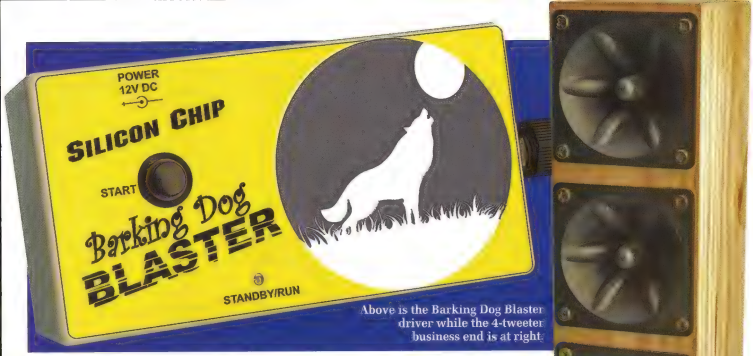
But we have something better and more effective than sympathy – our Barking Dog Blaster, or BDB. It won't hurt the dog but use the BDB judiciously and it should teach the dog to moderate its barking.

Now we're not being too optimistic here. The BDB won't solve the problem in all situations and we should mention some of them. For example, it won't work if the dog is old and deaf or too far away.

So if the offending creature is several doors down the street, it is not going to work. It should work with dogs in adjacent properties but beyond that, forget it.

Some dogs are just stupid or very aggressive and again, the BDB is probably not going to work in those situations. And nor will any barking dog deterrent completely

Features
- High volume ultrasonic sound bursts
- Adjustable timer
- Adjustable output frequency
- LED standby/run indicator
- Audible test
- Low standby quiescent current



Above is the Barking Dog Blaster driver while the 4-tweeter business end is at right.

stop barking; it is impossible to stop a dog from barking all the time, particularly if someone enters the property where they live.

Having said all that, the BDB can work well in many situations, particularly if the dog is within a distance of about 20m or thereabouts.

We are pretty confident in making this statement as we have published similar ultrasonic projects to know that they do work to help stop a dog barking. Two projects designed by SILICON CHIP (called Woofer Stoppers) were published in May 1993 and February 1996 and two projects, developed by Oatley Electronics (called Shut that Mutt) were published in July 1999 and April 2004.

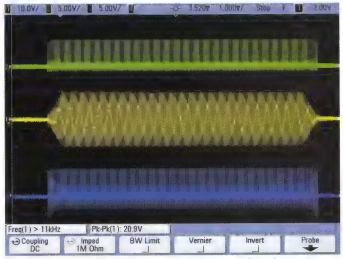
The BDB works, provided you use it sensibly. Each time the dog starts barking, you need to give it a burst of ultrasonic noise. It needs to associate the unpleasantness of the ultrasound occurring each time it barks.

Now we know that commercial ultrasonic barking deterrents are available in some pet shops but they use a single tweeter to produce the ultrasonic energy.

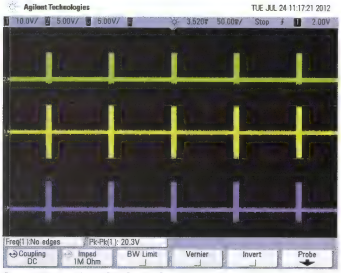
That's OK but our BDB is a much higher power device, employing four tweeters arranged as a "line source array" similar to a high-power PA speaker. The line source produces a narrower ultrasonic beam than a single tweeter and it can be aimed at the source to produce the maximum effect.

We need to do that in order for the dog to perceive the ultrasound as being loud.

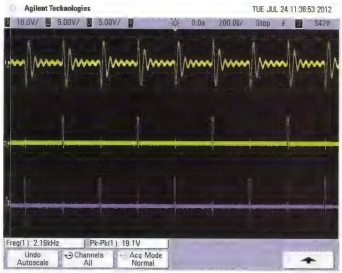
Scope 1: green and blue traces show the alternate 5V pulses at the Mosfet gates. The Mosfets then drive the transformer (T1) in push-pull fashion and the filtered output of its secondary (yellow trace) appears across the tweeters.



Scope 2: captured with a longer time base, this shows one entire burst being delivered to the tweeters. Burst duration is around 10ms. The ramp up and ramp down at either end minimise audible clicks from the tweeters during operation.



Scope 3: a series of pulses, showing the repetition rate of about 100ms. They start when the button is pressed and continue for the selected duration of 1-50s, or until it is pressed again.



Scope 4: voltage across the tweeters when operating in audible (test) mode. The frequency is around 2kHz while the duty cycle is extremely low; this time to avoid bursting your eardrums!

While dogs can hear ultrasonic frequencies, they need between 10 and 20dB more sound level to perceive the 25kHz to 30kHz frequency range at the same sound level compared to dogs' most sensitive frequency of 8kHz. (See www.lsu.edu/deafness/Hear-ingRange.html).

In addition, the tweeters of the BDB are pulsed on and off rather than being driven at a constant level. This allows them to be driven at a much higher level without the risk of being burnt out.

How will you know if the BDB is working, since humans cannot hear beyond 20kHz? We have provided an audible test mode whereby the BDB is driven at 1.5kHz but at considerably reduced level – so you won't be deafened. And when the BDB is working normally, you will hear a faint clicking, although you need to be reasonably close to it; within a few metres.

As can be seen in the photos, the BDB comes in two parts: the driver unit which is housed in a small plastic case and the line source tweeter array. The driver unit can be power from a 12V DC plugpack or a 12V battery. In standby mode it typically draws 106 microamps – so battery operation is quite feasible. The driver unit has a LED which flashes when the unit is in standby mode and it lights continuously when the BDB is doing its stuff.

Other animals?

There are many animals that have much better high-frequency hearing than humans. In the past, many readers – particularly those in the bush – have asked "would this work with kangaroos"? "What if I mounted one on the front of the ute, would it scare them off the road?"

Now we're no experts on these marsupials (except some say something about a few 'roos loose in the top paddock) so we can't really say yea or nay – but if you're troubled by Skippy, it could perhaps be worth a try.

But then again, our (admittedly limited) experience is that blasting 'roos with your car horn has little or no effect – they either keep hopping on their chosen path or just stand there staring at you – so maybe a blast of ultrasonics will have exactly the same effect.

One thing, though: the tweeter array is almost certainly not weatherproof so it couldn't be a permanent installation on the bull bar!

Circuit operation

The circuit for the BDB is shown in Fig.1 and is based on a PIC12F675 8-pin microcontroller, IC1. This is used to drive two Mosfets, Q1 & Q2 and these in turn drive transformer T1. The transformer output drives the piezo tweeters via a series resistor and parallel inductor. IC1 also drives the standby/run LED, powers trimpot VR1 and monitors the start switch.

IC1 is normally in "sleep" mode, drawing only about 100µA. It's woken from this mode by pressing the start switch – this discharges the 10µF capacitor connected to its GP2 input (pin 5) via a 100Ω current-limiting resistor so this input is pulled low.

IC1 first sets the GP5 output (pin 2) high to drive LED1, via a 560Ω resistor.

This also pulls the top of VR1 high. It then acts as a voltage divider across the 5V supply. The voltage at VR1's wiper is monitored by input AN3 (pin 3) and is converted to a digital value by IC1. This sets the timer period. A low voltage at AN3 provides a short timer period while a higher voltage provides a longer timeout period.

Incidentally, VR1 is also used to adjust the output frequency, as we shall see later.

The trimpot is connected to GP5 (rather than directly to the 5V supply) to reduce the current drawn during standby to just under 2µA. Permanent connection would result in a 500µA continuous drain.

Under the control of its pre-loaded firmware, IC1 now drives the two Mosfets from its GP1 and GP0 outputs (pins 6 and 7) at a rate that varies between 25kHz and 30kHz. There is a dead time between when the gate of one Mosfet is driven off (to 0V), to when the second Mosfet is driven with a 5V gate voltage. The dead time prevents one Mosfet from switching on before the other has switched fully off, preventing momentary short circuit currents.

Gate drive to each Mosfet is via a 10Ω resistor to prevent oscillation at the threshold of switch on. The 5.1V zener diodes clamp any voltage produced at the gate due to capacitance between the drain and gate. The 10kΩ

pulldown resistors are included to ensure the Mosfets are held off before the GP1 and GP0 outputs are set to low outputs in the IC1 program.

Mosfets Q1 and Q2 drive the transformer in push-pull mode with one primary winding driven and then the other primary winding driven in an alternate fashion. This produces an AC waveform at the transformer secondary. The AC waveform is a square wave and is not an ideal wave shape to drive the piezo transducers. The sharp rise times of the waveform would produce audible clicks from the transducers.

So the square wave is filtered using a resonant circuit comprising a 200µH inductor and the 220nF total capacitance across the four piezo transducers. The resonance occurs at 24kHz and the 47Ω resistor isolates the low impedance drive of the transformer from the resonant circuit. The result of this filtering is a relatively clean sine wave over the 25 to 30kHz frequency range.

Saving power

Power for the circuit is from a 12V supply. Two 2200µF low-ESR capacitors bypass the supply rail. A 12V output is also included to power a UHF remote switch receiver (we'll look at this next month).

A 5V supply for IC1 is derived from the 12V supply (via reverse polarity protection diode D1) by means of a low quiescent current regulator, REG1. Input and output terminals of REG1 are bypassed with 10µF capacitors and IC1 is further directly bypassed with a 100nF capacitor.

The quiescent current drawn by REG1 is typically only 75µA. IC1 is normally in sleep mode where it is drawing around 10µA. It is woken by a watchdog timer periodically at approximately 0.5s intervals so that it can flash the LED momentarily. The standby LED (LED1) is flashed at a low duty cycle so the 5.4mA normally used to drive the LED is reduced to an average of 21µA. Overall current drain from the circuit is typically 106µA and this low power allows the BDB to be connected to a 12V battery without causing any noticeable discharge over time.

When driving the piezo tweeters, the BDB obviously draws more current – an average of around 350mA peak per piezo tweeter during the pulsing period. When using four tweeters, the

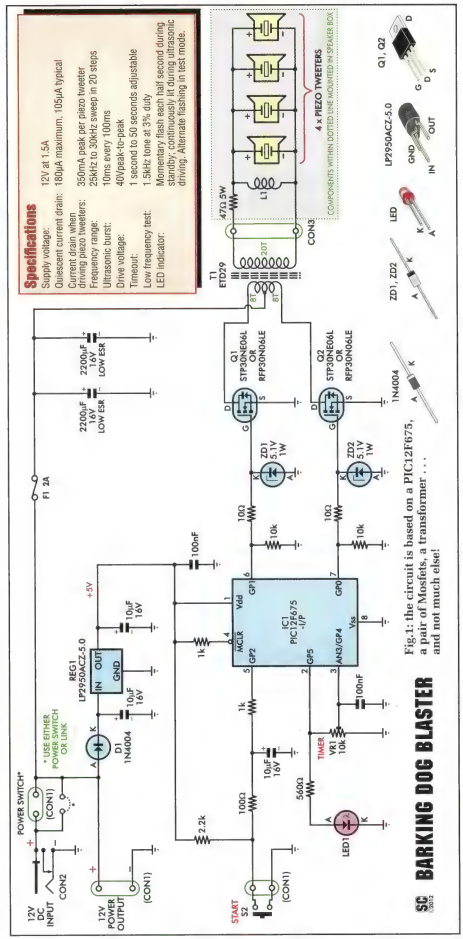


Fig.1: the circuit is based on a PIC12F675, a pair of Mosfets, a transformer . . . and not much else!

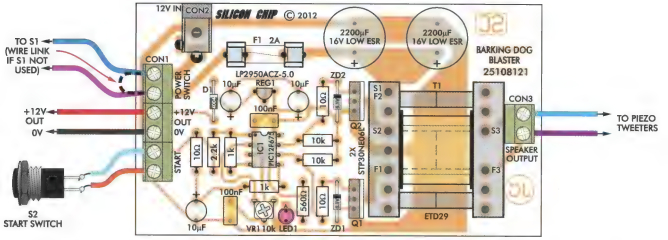


Fig.2: assembling the driver PCB shouldn't take you long – even the transformer is not too difficult to wind. The board is designed to fit into a UB3 Zippy box without the need for screws to hold it in place – athough there's space for mounting screws just in case you want to mount it somewhere else.

current rises to 1.4A. Total current drain depends upon how often and for how long the piezo tweeters are driven.

Because of the intermittent use of the BDB, this is still within the capabilities of most 12V batteries but if you use it often and have the time-out timer set towards the maximum end of the range (50s), the battery might not last too long at all.

Obviously, this circuit is NOT recommended for continuous operation – not only because the battery won't like it but the tweeters will also get a bit hot under the collar as well. It also somewhat defeats the whole purpose!

Some readers may wonder why we didn't use a microphone to trigger the circuit, as we have done in the past. The reason is quite simple – unless operating pretty close-by with gain down low, the circuit tended to trigger with every passing car, low-flying plane, loud voice, cat meow, ball bounce . . . you get the picture!

Assembly details

As mentioned earlier, the project is in two parts – the driver electronics and the piezo tweeter array. We'll start with the driver electronics.

With the exception of the four tweeters, inductor L1 and one 5W resistor, all components for the BDB are soldered onto a PCB coded 25108121, measuring 106 x 61mm. It is designed to clip into the integral side pillars of a UB3 box. The overlay diagram is shown in Fig.2.

Begin by checking the PCB for breaks in the tracks or shorts between them. Check also that the hole sizes are correct for each component to fit neatly. The screw terminal holes and transformer pin holes are 1.25mm, while larger holes again are used for the fuse clips.

Begin by installing the resistors, followed by the diodes. Table 1 shows the resistor colour codes but you should also check each resistor using a Digital Multimeter. Note that there are two different diode types: 1N4004 for D1 and 5.1V zener diodes for ZD1 and ZD2. The resistors are not polarised but the diodes certainly are!

IC1 is mounted on a DIL8 socket. Install this socket now, taking care to orientate it correctly. Leave IC1 out for the time being though. Fuse clips for F1 are installed next.

While fuses are of course not polarised, the fuse clips have an end stop to prevent the fuse from sliding out. So the clips must be oriented correctly and to ensure this, it's best to clip the fuse into the two clips first (with the end stops to the outside of the fuse) so that it holds the fuse in between the two clips. Then insert the clips into

The assembled PCB ready for connection to power and the "start" switch (via the 6-way terminal block at left) and the tweeter box (via the 2-way terminal block at right). Everything else is on the PCB. Provision is made for a power switch but we really don't think one is necessary – if you don't connect a power switch, wire a link between the top two terminals in the 6-way block.

the PCB and solder them in place.

A 6-way screw connector for CON1 is made using three 2-way connectors that are clipped together by sliding the dovetail mouldings on the sides of the terminals together. When mounting, make sure the screw terminals are oriented with the opening toward the outside edge of the PCB. CON3 comprises just a single 2-way screw terminal.

Q1 and Q2 mount vertically with the top of each tab 24mm above the top of the PCB. LED1 is mounted with its top 30mm above the PCB (its anode (A) has the longer lead). The capacitors can then go in, followed by trimpot, VR1. Make sure that the electrolytic capacitors are oriented correctly.

Transformer details

It's unlikely that you will find a transformer wound to our specifications so you're going to have to wind it yourself. It's not hard to do – Fig.3 shows the transformer winding details. The primary winding uses eight turns of figure-8 20 x 0.18mm wire, wound in two layers of four turns each. The secondary uses 0.8mm enamelled copper wire wound in one layer of 20 turns.

The secondary winding is done first. To do this, first strip say 10mm of the enamel from one end of the 0.8mm enamelled copper wire using some fine emery paper or a hobby knife to scrape it off. Pre-tin the wire end, wrap it around pin 4 on the underside of the transformer bobbin and solder it close to the bobbin.

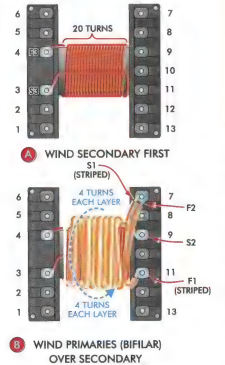


Fig.3: transformer winding detail.

Now wind on 20 turns side-by-side. The direction of winding (whether clockwise or anticlockwise) doesn't matter. Cover this winding layer with a single layer of plastic insulation tape. Now run the wire down perpendicular to these windings and terminate the wire onto terminal 3 and cover this perpendicular length with a layer of insulation tape.

The primary winding, made from the figure-8 cable, is first stripped of 10mm of insulation at one end and the two wires are soldered to pins 7 & 9 of the bobbin, with the polarity stripe to pin 7. Now wind on four turns making sure the wire lies flat without twists, so that the striped wire stays to the right. The four turns should fully fill the bobbin and the next four turns will be on the next layer (there's no need for insulation tape between them).

Terminate the polarity striped wire end onto pin 11 and the other wire to pin 7. Once wound, slide the cores into the former and secure with either a 200mm long cable tie or with clips. These clips push onto the core ends

Parts List – Barking Dog Blaster

1 PCB coded 25108121, 106 x 61mm
1 UB3 box 130 x 68 x 44mm
4 piezo tweeters (Motorola/CTS KSN1005A or equivalent) (or Jaycar CT-1930)
1 ETD29 transformer (13-pin former and N97 cores) (T1)
(element14 cat 1422746 for the former and 1422745 for the cores (2 required)
1 200mm cable tie to secure the transformer cores
1 28 x 14 x 11mm powdered iron toroid (Jaycar LO-1244) (L1)
2 M205 fuse clips
1 2A M205 fast blow fuse (F1)
4 2-way PCB mount screw connectors with 5.08mm pin spacings (CON1,CON3)
1 SPST momentary push button switch (Jaycar SP0700, Altronics S1084) (S1)
1 SPDT or SPST toggle switch (S2) (optional)
1 PCB mount DC connector (CON2)
1 DIL8 IC socket
1 cable gland for 3-6mm cable
1 1.2m length of 0.5m enamelled copper wire
1 1.2m length of 0.8mm enamelled copper wire
1 600mm length of 20 x 0.18mm figure-8 wire
1 60mm length of medium-duty hookup wire

Semiconductors

1 PIC12F675-I/P microcontroller programmed with 2510812A.HEX (IC1)
1 LP2950ACZ-5.0 low quiescent current 5V regulator (REG1)
2 STP30NE06L or RFP30N06LE logic-level Mosfets (Q1,Q2)
1 1N4004 diode (D1)
2 5.1V 1W zener diodes (ZD1,ZD2)
1 high-brightness 3mm LED (LED1)

Capacitors

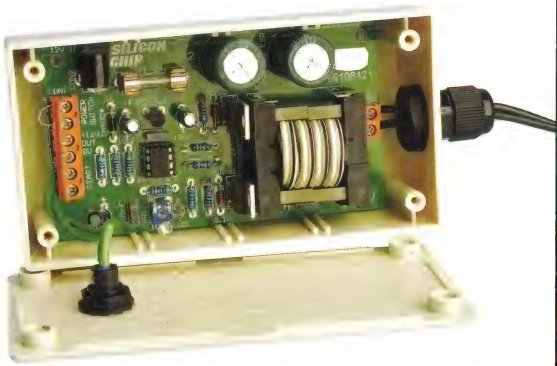
2 2200µF 16V low ESR electrolytic capacitors
3 10µF 16V electrolytic capacitors
2 100nF MKT polyester

Resistors (0.25W, 1%)

2 10kΩ 1 2.2kΩ 2 1kΩ 1 560Ω 1 100Ω 2 10Ω
1 47Ω 5W
1 10kΩ mini horizontal mount trimpot (VR1)

Speaker box

1.3m length of 90 x 12mm DAR pine (+ extra 356mm for rear backing panel if used)
16 No.6 x 15mm round head screws or similar
1 length of 20 x 0.18mm figure-8 wire (length as required)
1 cable gland (if required – see text. Alternative is mono 6.35mm socket and plug).
1 bracket for cable gland or socket (see text)



Here's how the driver PCB fits inside the UB3 box. No screws are required because the board is made to snap into the cutouts in the side guides. The two leads shown in the terminal block on the left go to the "start" switch on the front panel; no wiring is shown here for the on/off switch, should you decide to fit one. If you don't, a wire link should be connected between the top two terminals of the group.

and clip into lugs on the side of the bobbin.

The transformer can now be installed on the PCB. Note that its primary side has seven pins and the secondary side has six pins, so it can only go in one way.

That completes the PCB assembly.

Front panel

The front panel label can be downloaded as a PDF file from our website. You can print it out onto paper or clear overhead projector film. Now mark out and drill the holes in the lid of the case for switch S2 (and S1 if used) and for the LED.

For longest life, we laminate the label using an office laminator (they are ridiculously cheap these days!).

The label can be attached to the lid with spray adhesive, double-sided tape or silicone sealant. If you use double-sided tape be very careful when placing the label as you only get one shot at it!

The hole for switch S1 is cut out of the panel label using a sharp hobby knife or leather punch. Its position is shown on the panel artwork. A hole is required along one side of the box for the power plug entry and another at the end of the box for the cable gland for the lead connection to the piezo tweeters.

If the power switch is not required, bridge the two power switch terminals with a short length of tinned copper wire. Wire the start switch using the hookup wire by soldering wires to the switch terminals and terminating into the start switch terminals. Fig.2 shows the details.

Speaker box

A box for the four in-line piezo tweeters can be made using 90 x 12mm DAR (dressed all round) radiata pine timber. The diagram in Fig.4 shows the dimensions. Note that we used 19mm timber 'cause that's what we had, but we then needed to cut away some of the sides inside the box so the tweeters would fit. Using 12mm timber will allow the tweeters to fit without any doctoring of the timber. The 76mm holes are cut out using a hole saw or a jig saw. The timber is cut to size and glued together with PVA glue.

Weatherproofing the box will be necessary if it cannot be installed under cover. Additionally, a weather proof box will need a back panel on the box and the whole box painted. The backing can be 356 x 66 x 12mm to fit flush inside the back hole of the box or 380 x 90 x 12mm and mounted on the back, adding 12mm to the speaker box depth.

The piezo tweeters are secured with the No.6 x 15mm round head screws. Countersunk screws could be used instead, provided they are not made too tight as they can otherwise crack the plastic around the hole of the piezo tweeter casing. For weatherproofing, seal the mounting of the tweeter against the timber, preferably with speaker sealant.

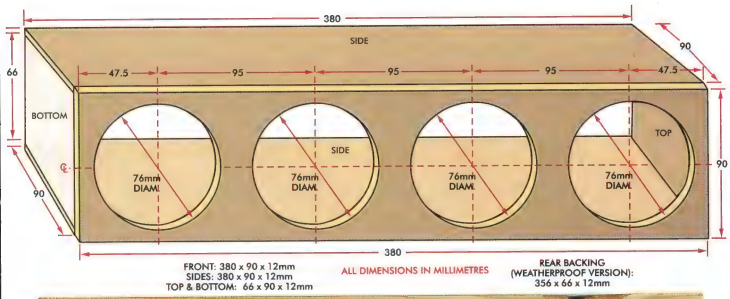
If you use silicone sealant, this will make removal of the tweeters difficult unless you first coat the back of the tweeters with some mineral oil to stop

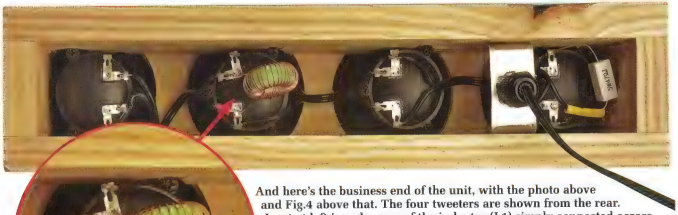
Capacitor Codes

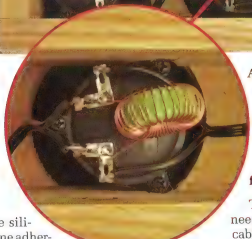
Value	µF Value	IEC Code	EIA Code
100nF	0.1µF	100n	104

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	1	560Ω	green blue brown brown	green blue black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	2	10Ω	brown black black brown	brown black black gold brown







And here's the business end of the unit, with the photo above and Fig.4 above that. The four tweeters are shown from the rear. Inset at left is a close-up of the inductor (L1) simply connected across one of the tweeters (which are all in parallel). The 47Ω 5W resistor connects in series with one of the leads coming from the driver. This shot shows another cable gland to keep the cable captive; if you want to make the speaker box detachable, you could use a 6.35mm socket and plug instead. While these photos show the box horizontal for convenience, in fact it should be used vertical to achieve the desired "beam" effect.

the silicone adhering to the plastic.

Before wiring the piezo transducers, inductor L1 should be wound. This has 39 turns of 0.5mm enamelled copper wire on a 28 x 14 x 11mm powdered iron core.

The tweeters are wired up in parallel (with all plus terminals wired together and all minus terminals wired together). The inductor is simply soldered between the + and – terminals of one of the tweeters (ie, in parallel). You'll need to scrape off a little of the wire insulation to allow it to be soldered

A 47Ω 5W series resistor connects between the + terminals of the tweeters and one of the incoming wires from the driver unit. The other wire goes direct to the negative tweeter terminals.

The external connection wire will need to be clamped to the box. For cable anchoring, you can use a cable gland attached to a suitable bracket screwed to the timber.

Alternatively, if a rear panel is used, the cable gland can be mounted into this. Or you could use a suitable plug and socket (eg, a 6.35mm mono) to allow the tweeter box to be disconnected from the driver unit.

Testing

Before going further, remove fuse F1 and check that IC1 has NOT been fitted to its socket. Apply power and check there is between 4.94V and 5.06V across pins 1 and 8 of the IC1 socket. If the voltage is outside this range, check for short circuits or open circuit solder connections or incorrectly placed or oriented components. If the voltage is OK, then switch off power and insert the fuse and IC1 making sure that IC1 is oriented correctly. Adjust VR1 to mid position (for a 25 second timer).

Connect the piezo tweeters to the BDB. Press and hold the start switch and connect power. The LED should flash on and off at about three times per second.

When the switch is released, the LED should begin flashing at a one second rate. Pressing the switch should start the BDB and the piezo should sound continuously at 1.5kHz (ie, well within your hearing range) at a relatively low volume. This is the test tone and the LED should flash three times per second.

The test tone will continue until the timer has timed out or the start switch is pressed. The BDB then automatically reverts to the normal ultrasonic sound delivery. Now the LED will briefly flash once every half second.

Fig.5: you can photocopy this label and glue it to the front panel or you can download it and print it out from siliconchip.com.au

The ultrasonic tone is started with the start switch and will either time out or it can be stopped by pressing the start switch again.

To return to the audible test tone, power must be switched off/disconnected for several seconds so the voltage on IC1 dies away to 0V. Press and hold the start switch and apply power to obtain the test frequency as described before.

Training the barking dog

When used to train the barking dog, the timer duration should be set to a length sufficient to stop the dog barking but ideally should not run longer than the barking duration. Timer settings are from 1s when the trimpot is set fully anticlockwise to 50s when set fully clockwise. The timer can be stopped immediately while running by pressing the start switch.

Mounting the tweeter box

The tweeter box should be located as close as reasonably possible to where the troublesome pooch resides (although this may sometimes be difficult!).

It operates best when it is used vertically although you can use it horizontally at short range if space is not available.

The box can be mounted with suitable brackets onto a tree trunk, under the eaves of the house or on a fence post as appropriate. Make sure the speakers are facing in the direction of the dog.

It's best if the box is tilted downward slightly, aimed to cover the entire barking dog area. Best orientation for sound coverage can be determined using the test frequency (if that is practical).

Adjusting the frequency

What if Yap-yap doesn't seem to show any reaction to your attempts to shut him up? Perhaps the BDB is putting out a frequency that he doesn't find too disturbing so doesn't react to it.

So we've made provision to alter it to a frequency he will not like so much . . . hopefully!

This is done with a combination of the start switch and VR1. With this adjustment, the frequency can be altered by up to 10kHz. The procedure is to hold down the start switch for eight seconds.

Note that this is different to the procedure to obtain the human-audible tone where the power must be switched off and then on with the start switch pressed.

For the frequency adjustment, the power is left on.

After the eight seconds, the piezo transducers will now be driven with bursts that can be adjusted in frequency by the trimpot (VR1).

Fully anticlockwise, VR1 will set the frequency to below 20kHz and fully clockwise, the frequency will be set for above 30kHz. The adjustment can be made for the lowest frequency that is inaudible.

The BDB will continue cycling bursts of signal every few seconds so long as the start switch is kept pressed.

Frequency will change with changes to the trimpot VR1 position. When the switch is released, the bursts will stop and the revised frequency for the bursts will be stored in EEPROM and this is the new BDB frequency unless changed again through this adjustment procedure. SC

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With this USB interface you can turn your desktop or laptop PC into a whole suite of test instruments – a 2-channel digital scope, spectrum analyser, AC DMM and frequency counter plus a 2-channel audio signal/function/arbitrary waveform generator. Interested? Read on.

By JIM ROWE

Six test instruments in one tiny box . . . just add your PC!

BACK IN THE October 2011 issue we presented an article on testing audio gear using PC-based sound card instrumentation and featured the TrueRTA software package. This is capable of quite respectable results but does have a few limitations, mainly due to those of the sound card.

In this article, we step up to a much more advanced set-up with a USB interface and a Windows-based audio testing package called *Multi-Instrument 3.2*, developed by Singapore-based firm Virtins Technology. This is a very professional software package and is reviewed elsewhere in this issue.

The interface described here is a development of the USB Recording and Replay Interface described in June 2011 and uses the same USB CODEC. For those familiar with that design, the input channel circuitry has been changed to be more similar to that of an oscilloscope/analyser and the output channel circuitry changed to be more like that of an AF signal/function/arbitrary waveform generator. Both the input and output channels have also been improved in terms of bandwidth, noise floor and crosstalk.

How it works

Since the heart of this project is the same Texas Instruments/Burr-Brown PCM2902 IC as in the June 2011 interface, we won't give the detail of its operation. If you want to know more, refer to the June 2011 article which gives an internal block diagram and discusses its operation in detail.

For our present purposes, it's enough to know that the PCM2902 is a single-chip stereo audio CODEC with an inbuilt full-speed USB protocol controller, a serial interface engine (SIE) and a USB transceiver. It provides a pair of 16-bit ADCs (analog-to-digital converters) capable of working at seven sample rates between 8ks/s and 48ks/s and also a pair of 16-bit DACs (digital-to-analog converters) capable

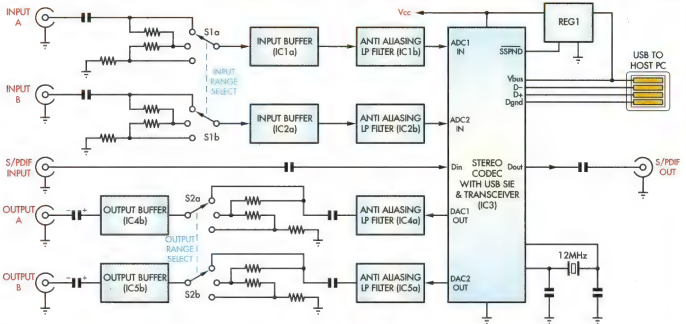


Fig.1: block diagram of the USB Virtual PC Instrument Interface. It's based on a PCM2902 stereo audio CODEC with an inbuilt serial interface engine and USB transceiver.

of working at three sample rates: 32, 44.1 and 48ks/s.

The PCM2902 contains internal firmware which makes it fully compliant with the USB 1.1 standard and it installs automatically on Windows XP SP3 and later versions of Windows, using the *USBaudio.sys* drivers.

Another nice feature of the PCM2902 is that it includes an output and an input for S/PDIF serial digital audio. It can process and analyse S/PDIF signals (from a DVD player or set-top box, for example), as well as being able to generate S/PDIF testing signals.

The basic configuration of the new interface is shown in the block diagram of Fig.1. This shows the PCM2902 (IC3), with its USB port at upper right. The analog input and output circuitry is all to the left, with the two ADC inputs at upper left and the two DAC outputs at lower left. The S/PDIF input can be seen at centre left, while the S/PDIF output is shown at centre right.

Each analog input channel has an input voltage divider and range switch which allows the input signals to be either passed straight through or attenuated to prevent overload. The input dividers and switches provide three input ranges for each channel: x1, x0.1 and x0.01. This allows the input channels to handle signals of 1.7V p-p (peak-to-peak), 17V p-p and 170V p-p, respectively.

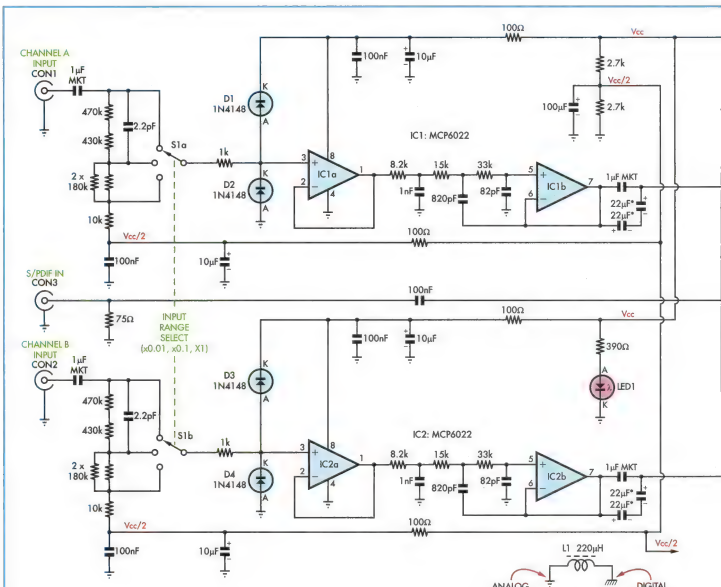
An input buffer (IC1a & IC2a) follows the range switches in each input channel. These then feed the signals to anti-aliasing low-pass filters to remove any possible signal components above about 23kHz (which would cause aliasing). The outputs of the LP filters in turn feed into the two ADC inputs of the CODEC (IC3).

The analog "generator" output channels are almost a mirror image of this configuration. The outputs of the DAC first pass through more anti-aliasing LP filters to remove any sampling "hash" and are each then fed to another voltage divider/switch combination to provide three output ranges: x1, x0.1 and x0.01, producing maximum output signal levels of nominally 0-2.12V peak-to-peak, 0-212mV p-p and 0-21.2mV p-p. The signals from the output range switches then pass through buffer stages IC4b & IC5b to the output connectors.

So that's the basic configuration. Now we can refer to the diagram of Fig.2 for the full circuit details.

The input circuitry for channel A

The unit is built into a diecast metal case which provides the necessary shielding.



SC 03012 USB VIRTUAL PC INSTRUMENT INTERFACE

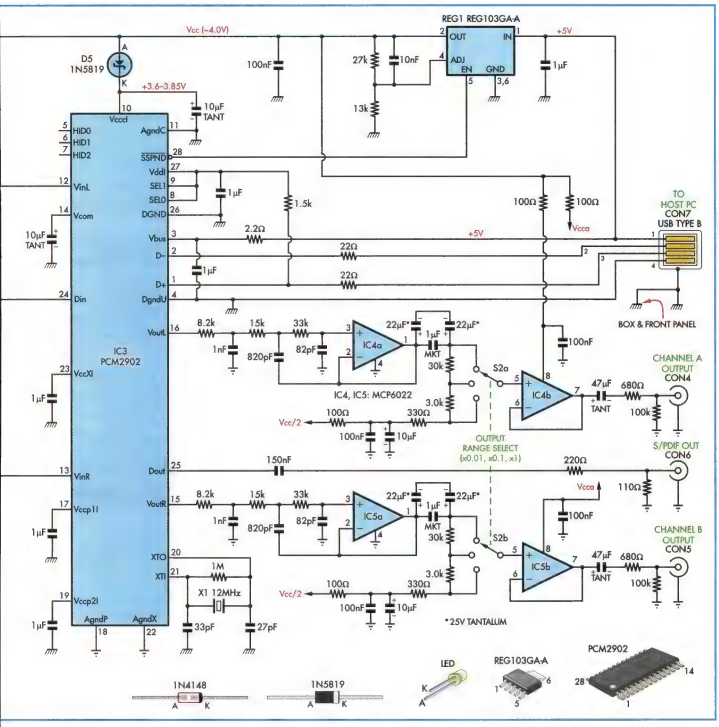
Fig.2: the complete circuit diagram of the USB interface unit. IC1a & IC1b and IC2a & IC2b are the input buffers and low-pass filters for the Channel A and Channel B inputs, while IC4a & IC4b and IC5a & IC5b provide filtering and buffering for the output signals. IC3 is the stereo audio codec – it provides the ADC & DAC stages, generates the USB signals and handles S/PDIF input and output signals.

is shown at upper left, while that for channel B is shown below it. Both channels are virtually identical, with channel A using the two op amps inside IC1 and channel B using those inside IC2. IC1 and IC2 are Microchip MCP6022 devices, selected because they offer impressive bandwidth, noise and distortion performance when operating from a relatively low single-supply voltage, which in our case is only 4V.

The input signals from CON1 and CON2 are fed through 1µF DC blocking capacitors to the input dividers and the two sections of range switch S1. The signals selected by S1a and S1b then pass through 1kΩ current limiting resistors before being applied to the inputs of IC1a and IC2a, with diodes D1/D2 and D3/D4 used to limit the voltage swing at each input to a maximum of Vcc + 0.65V and a minimum of -0.65V.

Note that since the pin 3 inputs of IC1 and IC2 are biased at Vcc/2 (ie, half the supply voltage), this allows the voltage swing to be over the full supply range.

The outputs of LP filter stages IC1b and IC2b are each fed to the ADC inputs of IC3 (pins 12 & 13) via non-polarised coupling capacitors of approximately 12µF. These are made up from two series 22µF tantalum electrolytics connected in parallel with a 1µF metallised polyester capacitor. This has been done to extend the low-frequency response of the input



channels to an acceptable level, with the modest input impedance (30kΩ) of the ADC inputs.

The S/PDIF input connector (CON3) is terminated via a 75Ω resistor. It is then connected to the digital input (pin 24) of IC3 via a 100nF coupling capacitor.

The two analog output channels of the interface are shown at lower right in Fig.2, connected to the DAC outputs of IC3 (pins 16 & 15). Again, the two output channels are virtually identical, with IC4a and IC5a providing the LP filtering and IC4b and IC5b forming the output buffers. IC4 and IC5 are again the same MCP6022 devices used in the input channels.

The two sections of switch S2 are used for output range switching, in conjunction with their voltage dividers. As with the input channels, the outputs of IC4a and IC4b are coupled to their respective dividers via 12µF coupling capacitors, to achieve an acceptable low-frequency response. That's also the reason for the 47µF capacitors used to couple the outputs of IC4b and IC5b to output connectors CON4 and CON5. The 680Ω resistors connected in series with each output provide short-circuit protection.

The S/PDIF digital output of IC3 (pin 25) is coupled to output connector CON6 via a 150nF capacitor and two resistors, selected to give the S/PDIF output a source impedance very close to the correct value of 75Ω.

As with the June 2011 Interface, the

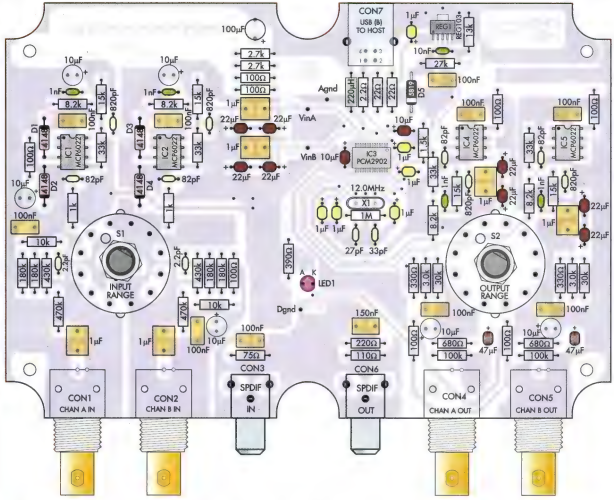


Fig.3: install the parts on the PCB as shown here, starting with the surface-mount device IC3. Note that this layout shows the tracks on the top side of the PCB only; the tracks on the bottom have been omitted for clarity.

USB port of the PCM2902 CODEC (IC3) connects to the USB host connector CON7 via the recommended component values. The power for all of the interface circuitry is derived from the V_{bus} pin (1) of CON7 but is connected to the rest of the circuit via REG1, a REG103GA low dropout (LDO) regulator which can be enabled or disabled via its EN input (pin 5).

This is done so that the current drain of the interface can be switched down to a very low value when the host PC's USB controller indicates to the CODEC's serial interface engine (SIE) that it should drop into "suspend" mode.

When the SSPND-bar output of IC3 (pin 28) rises to a high logic level to indicate the end of suspend mode, REG1 is turned on and delivers supply voltage (Vcc – approximately 4.0V) to the rest of the circuit – including the ADC and DAC circuitry inside IC3 itself. This receives a supply voltage of around 3.8V, via Schottky diode D5.

LED1 is driven from the Vcc line via a 390Ω resistor. LED1 indicates when the Interface has been activated (it remains off in suspend mode), as well as serving as a power-on indicator when the Interface is in use.

L1 is used to provide a connection between the digital and analog grounds within the circuit – a connection which represents a low impedance at low frequencies but a higher impedance at high frequencies. This helps to keep digital hash out of the analog sections of the circuit and improves the overall noise performance.

Construction

All the parts used in the USB Interface are mounted on a double-sided PCB coded 24109121 and measuring 160 x 109mm. This fits inside a diecast aluminium box measuring 171 x 121 x 55mm (Jaycar HB-5046 or similar), to provide physical protection as well as effective shielding.

The PCB is mounted on four M3 x 25mm tapped spacers behind the lid of the box. The spindles of switches S1 and S2 pass through matching holes in the lid, as does the body of LED1.

USB connector CON7 is mounted at the rear of the PCB and when the PCB and lid are fitted to the box, CON7 is accessed via a rectangular hole in the rear. All of the other I/O connectors (CON1-CON6) are mounted along the front of the PCB, with the input sockets to the left and the output sockets to the right.

These all pass through matching holes at the front of the box, when the PCB and lid are fitted. Hence, there is no wiring at all, apart from a single lead which connects the metal box to the earth of the PCB.

Fig.3 shows the parts layout on the

This view shows the completed PCB, ready for installation on the case lid. Be sure to install the two switches with their spigots at 11 o'clock, as shown on Fig.3.

PCB. You should follow it closely regarding the placement and orientation of the various components.

Begin the PCB assembly by fitting the two SMD components, IC3 and REG1 (it's easier to solder these in place when none of the other components are installed). Use a temperature-regulated iron with a fine chisel or conical point and hold each device in position carefully using a toothpick or similar tool while you tack-solder two pins that are well separated from each other.

These will hold the device in position while you solder the rest of the pins; make sure that the originally tacked pins are properly soldered as well. Don't worry if you accidentally create solder bridges between adjacent pins – these are almost inevitable and can be removed at the end of the soldering procedure using fine solder wick braid (an illuminated magnifier is handy when it comes to checking for solder bridges).

With IC3 and REG1 installed, you can fit the various passive components, starting with the resistors. These should be all 0.25W 1% metal film types, with the exception of the 2.2Ω unit just below CON7. This one needs to be a 0.5W or 0.625W type. Fit the 220µH RF inductor (L1) at this stage as well, just below CON7.

Now fit the various capacitors. Make sure that you don't confuse the 10µF tag tantalum types with the 10µF aluminium electrolytics and take care to fit all of these polarised components the correct way around. To help in this regard, Fig.3 shows the tantalum capacitors in brown, while the aluminium electros are shown as circles filled with pale blue.

After all of the capacitors are in place you can install the 12MHz clock crystal for IC3, which fits just to the front of IC3 and alongside the 1MΩ biasing resistor.

Next, install the 1N4148 diodes D1-D4 which are located just to the left of the sockets for IC1 and IC2. The last diode to fit is D5 (1N5819) which goes midway between IC3 and REG1.

The input and output connectors (CON1-CON7) are next. Then fit the 8-pin sockets for IC1, IC2, IC4 and IC5, taking care to orientate them with their notched ends towards the rear of the board as shown in Fig.3.

Table 1: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
1µF	1µF	1u	105
150nF	0.15µF	150n	154
100nF	0.1µF	100n	104
10nF	.01µF	10n	103
1nF	.001µF	1n	102
820pF	NA	820p	821
82pF	NA	82p	82
33pF	NA	33p	33
27pF	NA	27p	27
2.2pF	NA	2p2	2.2

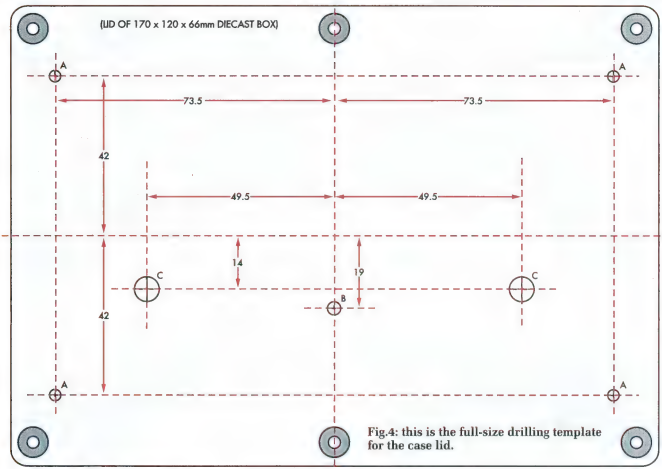


Fig.4: this is the full-size drilling template for the case lid.

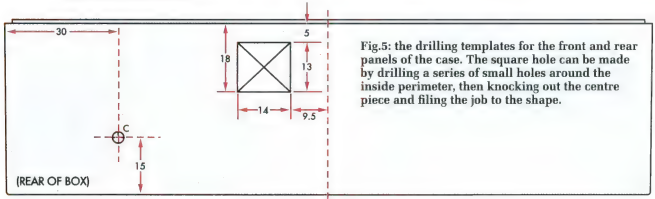
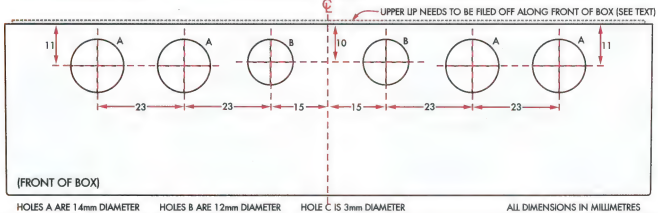


Fig.5: the drilling templates for the front and rear panels of the case. The square hole can be made by drilling a series of small holes around the inside perimeter, then knocking out the centre piece and filing the job to the shape.



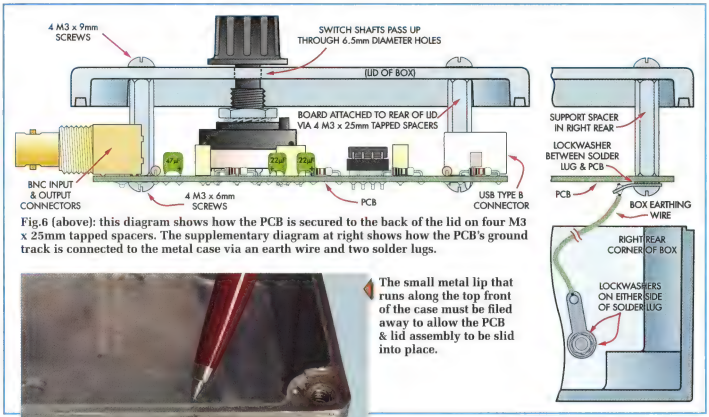


Fig.6 (above): this diagram shows how the PCB is secured to the back of the lid on four M3 x 25mm tapped spacers. The supplementary diagram at right shows how the PCB's ground track is connected to the metal case via an earth wire and two solder lugs.

The small metal lip that runs along the top front of the case must be filed away to allow the PCB & lid assembly to be slid into place.

Switches S1 and S2 can now be installed. Before you fit them, their spindles should be cut to a length of 16mm so they'll protrude through the front panel by the correct amount when the board assembly is fitted to it. The plastic spindles can be cut quite easily using a hacksaw and any burrs smoothed off using a small file. Then the switches can be fitted to the board. Orientate them as shown in Fig.3, with their spigots at 11 o'clock. Press them down firmly against the top of the PCB and then solder all of their pins to the pads underneath.

Now try turning the switch spindles to check that they are correctly set for three positions. If not, you'll need to first rotate each switch fully anti-clockwise, then remove the nut and lockwasher before lifting up the stop pin washer and refitting it with the pin passing down into the correct hole (ie, between the moulded 3 and 4 numerals). Finally, refit the lockwasher and nut to hold everything in place.

The final component is LED1, located just below the centre of the board with its cathode "flat" towards the right. It is mounted in the upright position, with the lower surface of its body about 24mm above the top surface of the board. Just tack-solder one lead to hold the LED in place while the board is fitted behind the box lid.

You will be able to adjust the height of the LED later, so that it protrudes nicely through the front panel. Both solder joints can be finalised then.

The last step in completing the PCB assembly is to plug the four MCP6022 ICs into their sockets, each one with its notch end towards the rear of the board and also making sure that none of their pins become buckled. It's also a good idea to earth yourself before handling them, because they can be damaged by electrostatic charge.

Preparing the lid and the box

Before the completed PCB assembly can be attached to the box lid, you'll need to drill holes in the lid to match the screws for the mounting spacers. In addition, you need to drill clearance holes for LED1 and the spindles of S1 and S2. The locations and sizes of all of these holes are shown in Fig.4, which is reproduced actual size so it can be used as a drilling template if you wish. As you can see there are only seven holes to be drilled in all, so preparing the lid is quite easy.

The drilling diagram for the box is shown in Fig.5. Six holes need to be drilled using a pilot drill and then carefully enlarged to the correct size using a tapered reamer. The rectangular hole for USB connector CON7 can be made by drilling a series of small holes around the inside perimeter, then knocking out the centre piece and filing the job to the final rectangular shape.

When all holes are complete, you will need to file away the small lip running along the top of the front of the box, as indicated by the note in Fig.5. This is necessary because when the lid and PCB assembly are being introduced into the box during final assembly, if the lip is still present it just prevents the front of the PCB from being lowered enough for BNC connectors CON1, CON2, CON4 and CON5 to pass through their matching holes.

A professional front panel will be available for sale from the SILICON CHIP

PC Instrument Interface: Parts List

1 diecast aluminium box, 171 x 121 x 55mm (Jaycar HB-5046 or similar)
1 PCB, code 24109121, 160 x 109mm
1 front panel PCB, code 24109122
1 12.00MHz HC49U/US crystal (X1)
1 220µH RF choke, axial leads (L1)
2 4-pole 3 position rotary switches (S1,S2)
4 PCB-mount BNC connectors (CON1-CON2, CON4-CON5)
2 PCB-mount switched RCA sockets (CON3, CON6)
1 USB type-B connector, PCB-mount (CON7)
4 8-pin DIL sockets, machined pin type
2 instrument knobs, 24mm dia.
4 M3 x 25mm tapped spacers
5 M3 x 9mm machine screws
4 M3 x 6mm machine screws
1 M3 nut
2 3mm solder lugs
3 3mm star lockwashers
1 120mm-length of insulated hookup wire

Semiconductors

4 MCP6022 dual op amps (IC1,IC2,IC4,IC5)
1 PCM2902 audio CODEC (IC3) (Element14 8434700)
1 REG103GA-A low-dropout regulator (REG1) (Element14 1207256)
1 3mm high-intensity red LED (LED1)
4 1N4148 100mA diodes (D1-D4)
1 1N5819 1A Schottky diode (D5)

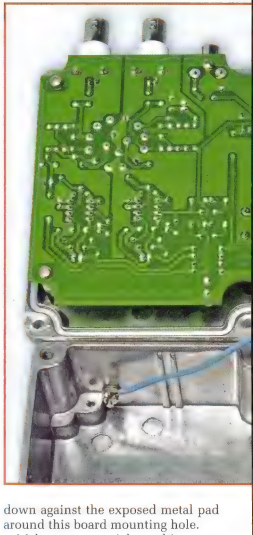
Capacitors

1 100µF 16V RB electrolytic
2 47µF 16V tantalum electrolytic
8 22µF 16V tantalum electrolytic
6 10µF 16V RB electrolytic
2 10µF 16V tantalum electrolytic
6 1µF monolithic ceramic
6 1µF MKT polyester
1 150nF MKT polyester
10 100nF MKT polyester
1 10nF MKT polyester
4 1nF polyester (greencap)
4 820pF 50V disc ceramic
4 82pF 50V disc ceramic
1 33pF 50V NP0 disc ceramic
1 27pF 50V NP0 disc ceramic
2 2.2pF 50V NP0 disc ceramic

Resistors (0.25W, 1%)

1 1MΩ	2 2.7kΩ
2 470kΩ	1 1.5kΩ
2 430kΩ	2 1kΩ
4 180kΩ	2 680Ω
2 100kΩ	1 390Ω
4 33kΩ	2 330Ω
2 30kΩ	1 220Ω
1 27kΩ	1 110Ω
4 15kΩ	8 100Ω
1 13kΩ	1 75Ω
2 10kΩ	2 22Ω
4 8.2kΩ	1 2.2Ω 0.5W
2 3.0kΩ	

Note: the PCB & front panel are available from the SILICON CHIP Partshop.



Partshop. This is basically a screen-printed PCB and is supplied with all the holes pre-drilled.

Final assembly

The PCB and lid assembly is shown in Fig.6. Four M3 x 25mm tapped spacers are attached to the rear of the lid using four M3 x 9mm machine screws (which also pass through the matching holes in the dress front panel, on the top of the lid). These screws should be tightened firmly, without causing buckling of the dress panel around the screw heads.

Next, the PCB can be offered up to the lower ends of the spacers, taking care to ensure that the spindles of S1 and S2 align with their matching holes in the lid and that the body of LED1 enters its own matching hole. Then when the PCB is resting on the spacers the complete assembly can be turned over and three M3 x 6mm screws installed to attach the board to three of the four spacers: the two at the front corners of the PCB and the one at the rear corner furthest from the USB connector CON7.

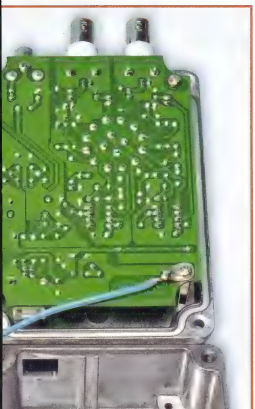
When these three screws have been fitted and tightened up to hold the board and lid together, the final screw can be fitted in the remaining corner spacer hole. This M3 x 6mm screw is also used to terminate an earthing wire from the box – so in this case it must be fitted with a 3mm solder lug and a star lockwasher, before being screwed down against the exposed metal pad around this board mounting hole.

Make sure you tighten this screw down securely, using a Phillips-head screwdriver and a spanner or small shifter to grip the spacer and prevent it from turning.

Now check the positioning of LED1 in its hole in the front panel. Adjust it if necessary before soldering both its leads to the PCB.

That done, you need to fit a 120mm long earth wire between the case and the PCB. This is attached at the case end via a 3mm solder lug that's secured by an M3 x 9mm screw to one corner of the box. Fit a star lockwasher to the screw, then add the solder lug and follow this with another star lockwasher. The other end of the earth wire is soldered to the lug previously attached to one corner of the PCB.

Once this wire is in place, remove the nuts from the front of the BNC input and output connectors (leaving the lockwashers in place) and lower the front of the lid and PCB assembly into the box until the BNC connectors pass through their matching holes in



The earth track of the PCB is connected to the metal case using a short earthing wire. This can be run to the right-rear of the case (not the left rear as shown here).

the front of the box. This will then allow the rear of the lid/PCB assembly to be lowered into the box as well, until the lid is sitting comfortably on the top of the box.

The lid can now be secured in place using four M4 screws (supplied with the box). Finally, refit the BNC connectors with their mounting nuts and then fit the knobs to the spindles of S1 and S2. Your Virtual Instrument Interface is now complete.

Checkout time

The only setting up adjustments you may need to make are in the operating system of the PC, as explained shortly. Checking out the Interface basically involves little more than connecting it to a spare USB port on either the PC itself or to a spare downstream port on an external hub connected to it.

Because the PCM2902 CODEC includes firmware which identifies itself as a *"Generic USB Audio CODEC"*, it usually installs automatically as soon as you connect it to a PC running Windows XP (SP3), Windows Vista or Windows 7.

Features & Specifications

A 2-channel virtual test instrument USB interface to suit to any Windows-based PC, powered from the PC's USB port. The two input channels and two output channels can all operate simultaneously. Also provided is an S/PDIF input and output. When used in conjunction with a suitable software package the interface allows the PC to be used as a 2-channel audio DSO and spectrum analyser combined with an AC DMM and a frequency counter, plus a 2-channel AF signal and function generator able to provide low-distortion sinewaves, a number of standard waveforms, white and pink noise, arbitrary waveforms and even DTMF signals and musical tones. Features of the Interface include:

- Input channels provide three switched sensitivity levels – x1.0, x0.1 and x0.01
- Nominal input sensitivity (x1.0 range) is 500mV RMS (1.414Vp-p/-3.8dBu).
- Maximum input level (x1.0 range) before clipping is 600mV RMS (1.70Vp-p/-2.2dBu).
- Input impedance (both channels) is 1MΩ//20pF.
- Effective noise floor of the input channels is at -99dBu (2.5μV).
- Two high-quality 16-bit ADCs capable of operating at sampling rates of 8, 11.025, 16, 22.05, 32, 44.1 and 48ksamples/s.
- Frequency response of input channels is as follows:
  21Hz – 8kHz +0/-0.15dB
  12Hz – 12.6kHz +0/-0.5dB
  6Hz – 16.3kHz +0/-1.0dB
  1.5Hz – 20kHz +0/-2.0dB
  <1Hz – 22kHz +0/-3.0dB
- Output channels provide three switched output levels – x1.0, x0.1 and x0.01.
- Nominal output level on the x1.0 range is 500mV RMS (1.414Vp-p/-3.8dBu).
- Maximum output level (x1.0 range) before clipping is 750mV RMS (2.12Vp-p/-0.28dBu).
- Output impedance (both channels) is 675Ω.
- Two high quality 16-bit DACs capable of operating at sampling rates of 32, 44.1 and 48ksamples/s.
- Frequency response of the output channels is as follows:
  4.6Hz – 17.0kHz +0.15dB/-0.5dB
  3.1Hz – 18.7kHz +0.15dB/-1.0dB
  1.2Hz – 20.5kHz +0.15dB/-2.0dB
  <1Hz – 22.0kHz +0.15dB/-3.0dB
- Crosstalk between channels, overall:
  below -62dB from 20Hz – 5kHz
  below -59dB from 1Hz – 10kHz
  below -56dB from 10kHz – 20kHz
- Crosstalk between output and input channels:
  as for between channels shown above
- THD+N for both channels, overall (ie, output-> input) for output/input levels of 0.5V RMS: at 100Hz, 0.075%; at 1kHz, 0.075%; at 5kHz, 0.1%
- S/PDIF input and output both handle 16-bit stereo signals at sampling rates of 32, 44.1 and 48ks/s.
- Fully compliant with the USB 1.1 specification
- Installs automatically on Windows XP SP3 and later Windows operating systems (plus Mac and Linux systems) using the standard USBaudio.sys drivers – no special or custom drivers required.
- Fully compatible with Windows-based Virtual Instrument software such as Virtins MI 3.2 (standard and Pro versions).
- Low current drain from PC via USB cable: less than 65mA

The PCB and lid assembly is slipped into the case as shown here. Don't forget to file away the metal lip at the top front of the case.

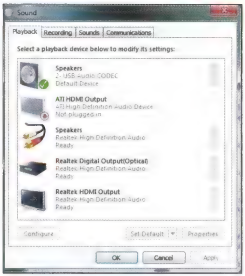


Fig.7: the Windows 7 *Sound* dialog box. The default playback device should be the "USB Audio CODEC".

After a few seconds, you should hear a greeting from the PC's sound system to indicate that the operating system has recognised that a new Plug and Play USB device has been connected. It then shows pop-ups from the System Tray as it identifies the device and automatically installs the standard USB audio drivers for it. LED1 on the Interface should also light as soon as the drivers are installed.

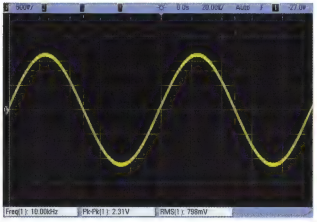
The next step is to check that this has all taken place correctly. In Windows XP, click the Start button, launch the Control Panel and double click on *"Sounds and Audio Devices"*. This should bring up the Sounds and Audio Devices Properties dialog. If you then click on the *"Audio"* tab you should see *"USB Audio CODEC"* listed in the drop-down device selection lists for both Sound Playback and Sound Recording. This should also be the case if you click on the "Voice" tab.

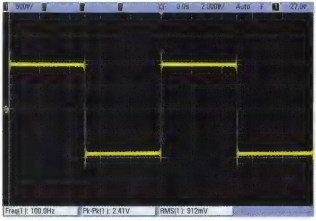
Now click on the *"Hardware"* tab and select *"USB Audio Device"*. You should see the following information in the Device Properties area:

Manufacturer: (Generic USB Audio)
Location: Location 0 (USB Audio CODEC)
Device Status: This device is working properly.

If you are using Windows 7, launch the Control Panel and select *"Hardware and Sound"*. Then double-click on *"Sound"*, which should bring up the dialog box shown in Fig.7. The *"Playback"* tab will be automatically selected, showing that the default playback device (labelled "Speakers") is the "USB Audio CODEC".

If you then select the *Recording* tab, this should show that the default recording device (labelled "*Microphone*") is again the USB Audio CODEC, as shown in the upper dialog in Fig.8. If you then click on the *Microphone* to select it and then click on the *Properties* button, this will open up the *Microphone Properties* dialog (the lower one in Fig.8), to confirm that





These two scope grabs show waveforms generated by the Virtins' Multi-Instrument 3.2 software and processed through the Virtual PC Instrument Interface. A 10kHz sinewave is shown at left, while at right is a 100Hz square wave.

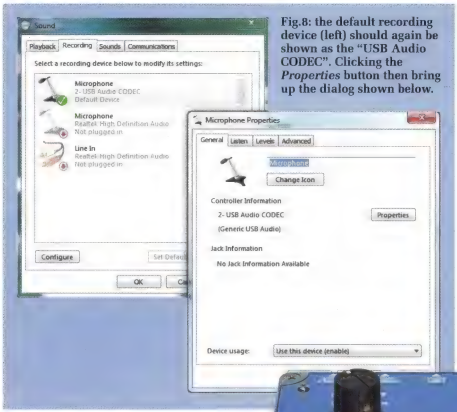


Fig.8: the default recording device (left) should again be shown as the "USB Audio CODEC". Clicking the *Properties* button then bring up the dialog shown below.

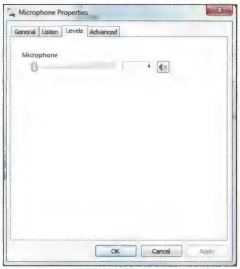


Fig.9 (above): selecting the Levels tab in Fig.8 brings up this dialog box. The Microphone slider control should be dragged to the left to give a level reading of "4" (see text).

the Interface is installed as a *Generic USB Audio* device.

Finally, you need to select the *Levels* tab at the top of the *Microphone Properties* dialog. This will display the Microphone mixer level control slider, as shown in Fig.9. Move the slider towards the lefthand end until the number displayed in the box to its right is "4" (see Fig.9).

This is the correct setting for our Virtual Instrument Interface, because the PCM2902 leads Windows to believe it is providing amplified signals from two microphones when it's really providing "line level" inputs. By setting the slider to "4", we trick Windows into believing the signals are effectively coming from line level inputs.

Once you have set the "Microphone" slider to 4, all that is necessary is to back out of these dialogs by clicking on the "OK" buttons in turn until you return to the Control Panel.

The USB socket is accessed via a square hole in the rear side panel of the case. Note that the case lid is held on using just four screws (one at each corner). The other two holes in the lid are covered by the front panel and are not used.

This can then be closed and your Virtual Instrument Interface will now be installed and ready for use.

Of course before you can do so, you'll need to install the Virtual Instrument Software you're planning to use with it. For details on installing and using Virtins' Multi-Instrument 3.2 please refer to the review article elsewhere in this issue. SC

PCM2902 Version Differences

The PCM2902 IC specified in this project (and the USB Stereo Recording/Playback Interface from July 2011) is the most common type currently available in Australia. However, Texas Instruments also has two newer versions of this chip: the PCM2902B and PCM2902C.

All three versions are pin-compatible and should work without any circuit changes. The later versions have some minor advantages: (1) the B and C versions are USB 2.0 compliant whereas the original is only USB 1.1 compliant; (2) the original chip had a one-sample recording delay between the left and right channels which has been fixed in the later revisions; and (3) the later versions are more tolerant of malformed S/PDIF input data. In addition, the PCM2902C identifies its analog inputs as line level inputs rather than microphone inputs, so you don't have to adjust the input gain before using it. It also has an onboard digital volume control.

PRODUCT SHOWCASE

Reality Technologies' Ultra Flat Panel Electrostatics

At first glance – indeed, even after a long, detailed look, these new "Sonic Blade" speakers probably don't look anything like the speakers you may be used to.

That's because they are nothing like the speakers you're used to. But once you listen to them, your perception of high fidelity sound reproduction might be changed forever.

Electrostatic speakers have been around for many decades (think Quad Electrostatics from the 1960s). But they certainly haven't enjoyed the popularity of conventional speakers.

Reality Technologies, who import and distribute these speakers in Australia, aim to change all that; change perceptions of what speakers should look like and change perceptions of what performance speakers should sound like.

With incredible detail and definition, these speakers are claimed to deliver everything artists and studios intended you to hear; detail and definition that many conventional speakers struggle to reveal.

Shown at right fitted to semi-transparent "stands", the UFPS-440 panels have a mere 8mm-thick profile. They would perfectly suit a bookshelf style system, a premium satellite surround system, or combined with a clean sub-woofer, floor-standing and hi-fi applications.

With an attractive panel that can be left as is or covered with fabric or mesh, the sound you want can be customised to fit whatever look and application you desire.

Frequency response of the panels is 200Hz - 20kHz with less than 1% THD. Sensitivity is quoted as 88dB and they would suit medium to high power amplifiers that can drive a minimum impedance of 4Ω.

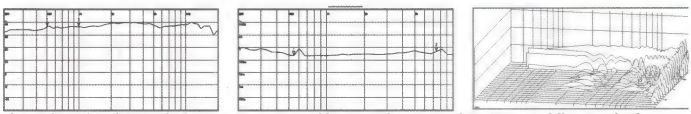
The panel dimensions are 168 x 440 x 8mm and they weigh just 440g. Each panel is supplied with a matching polarisation transformer (77 x 63 x 68mm; approximately 2.5kV).

They are available in both kit form and in production quantities. Because Reality Technologies are the importers, they can also arrange for the Sonic Blades to be manufactured in quantity at low cost – a first for high quality flat panel speakers.

So whether you're an audio afficionado looking for some real performance or an OEM looking for something different, you should contact Reality Technologies and ask them about their Sonic Blades. They will customise the panels to suit your application.

They can, of course, also supply all your other hifi components to match the performance of these remarkable loudspeaker systems. See the "products" section of their website (at right) for more details.

Contact:
Reality Technologies Australia
33-35 Malcolm Rd, Braeside, Vic 3195
Tel: (03) 8581 7638 **Fax:** (03) 9587 4986
Website: www.reality-design.com.au



Shown above (from left) are the frequency response, total harmonic distortion and 2m CSD waterfall pattern for the "Sonic Blade" UFPS-440 electrostatic panels.

Jaycar Electronics

Better. More Technical

FOR THE NO. 1 DAD

SEPTEMBER EDITION

Prices valid until 23/09/2012

Soldering Tool Set for Dad

The perfect gift for DIY DAD this Father's Day! Package worth $154.05 save over $25.

FATHER'S DAY DEAL

Includes:

1 x 48W Soldering Station (*TS-1564* $99.00)
1 x PCB Holder (*TH-1983* $12.95)
1 x Solder (*NS-3010* $10.95)
1 x Desolder Braid (*NS-3020* $3.25)
1 x Plier (*TH-1893* $13.95)
1 x Cutter (*TH-1890* $13.95)

$129.00 SAVE $25.05

3 Channel Double Blade RC Helicopter

Powerful 3 channel gyroscope equipped chopper.

- 2 switchable frequencies
- Remote requires 4 x AA batteries
- 70min charge time gives about 6-8min flight time
- Suitable for ages: 8+
- Size: 450(L) x 83(W) x 200(H)mm

GT-3530

$69.95

NEW STORE OPENING

Warners Bay NSW

2/276 Macquarie Rd

Ph: (02) 4954 8100

Parking available!

Noise Cancelling Headphones

Suitable for frequent flyers and travellers, these headphones reduce background noise by up to 16dB. The ear cups rotate for easy storage inside your hand-carry bag or seat pocket.

- High quality digital stereo sound
- Built-in rechargeable battery
- Airplane adaptor

AA-2088

GIFT IDEA

$69.95

Mains Timer Kit for Fans & Lights

Refer: Silicon Chip Magazine August 2012

This simple circuit provides a turn-off delay for a 230VAC light or a fan, such as a bathroom fan set to run for a short period after the switch has been tuned off. The circuit consumes no stand by power when load is off. Kit supplied with PCB, case and electronic components. Includes 220nF capacitor for 2.5 mins to 45 mins. See website for a list of alternate capacitors for different time periods between 5 seconds to 1 hour.

- Handles loads up to 5A
- PCB: 60 x 76mm

KC-5512

NEW $29.95

DUE MID SEPTEMBER

Slide/Film Scanner with LCD

Record images from your film negatives and slides. Each scan takes a matter of seconds so you can have a whole album archived in no time.

- 5.1 MP Camera
- 3,600 dpi scan resolution
- Includes slide/film holders, and brush cleaner
- Size: 87(L) x 88(W) x 105(H)mm

XC-4891 ***was $149.00***

GIFT IDEA

$84.95 SAVE $64.05

NOTE: SD/MMC card not included Limited Stock. Not available online.

HD Sports Camera

Records the thrills and spills of your action sport up to HD 720P, which can be played back on the 2" colour touch screen or by connecting to a PC. Features a photo taking mode, vehicle video cycle-recording mode and includes waterproof case, mounting straps, and in-car charging cables.

- Requires microSD card up to 32GB
- Records approx 6GB per hour
- Camera size: 67(L) x 47(W) x 29(D)mm

QC-8018

NEW $129.00

USB Business Card Scanner

Powered by USB and uses a 2MP sensor with fixed focus to capture clear images. Includes Optical Character Recognition software that extracts text from the business card. Doubles as a webcam with microphone.

- Size (folded): 95(L) x 37(W) x 14(D)mm

QC-3130

GIFT IDEA

NEW $49.95

Economy 4 Channel DVR

Designed for small surveillance systems in the home or office, it is capable of recording full D1 (704 x 576) resolution at 25 frames per second on each channel. Supplied with a 500GB HDD to store up to 300 hours of continuous video it can also be configured to trigger from a timer or motion detection. Connect to a computer network to view video remotely using a web browser or Smartphone/iPhone® (via installed app*).

- H.264 Compression
- Composite and VGA video output
- Size: 300(L) x 210(W) x 50(H)mm

QV-3029

NEW $279.00

*Free app for viewing live video available for download.

5.8GHz HDMI Sender/Receiver - 1080p

Wirelessly pipe a 1080p HDMI source to a HDTV in another room. Saves you the hassle of installing wallplates, crawling into wall cavities, or running messy HDMI cable around the house. Comes with IR remote control.

- Range: up to 25m
- Includes IR extender function
- Receiver/sender size: 154(H) x 92(W) x 20(D)mm

AR-1877

Also available: ***Spare receiver*** AR-1876 $149.00

4-input HDMI Switcher AR-1874 $49.95

AR-1874

AR-1877

NEW $249.00

FOR THE DIY DAD

New Tools for DIY Dad

Repair Kit for iPhone®

All the tools you need to take apart your iPhone® for DIY repair jobs, organised neatly inside a compact storage case. See website for contents.

- 19-piece
TD-2113

NEW $29.95

Long Bit Screwdriver Set

Tackle a wide range of fastening scenarios using our compact screwdriver set comprised of a selection of popular slotted, Phillips, Star and TRI bits, packed away neatly inside a handy storage case. See website for contents.

NEW $29.95

- 22-piece
TD-2114

15-pce Precision Hobby Knife Set

Handy hobby tool set comprising of 10 different blades, handle, tweezers, flat screwdriver and vernier calipers, which measure up to 80mm.

- Case size: 170(W) x 85(W) x 35(D)mm
TH-1916

NEW $19.95

Also available: *Spare Blades PK10 NEW* TH-1917 $5.95

DUE EARLY SEPTEMBER

Soldering Iron Kits Dad can Choose

20/130W Soldering Iron Starter Kit

All the soldering essentials for the hobbyist Dad. The sum of the individual parts is more than double the price we are selling this kit for. Excellent value! See website for contents.
TS-1651

$24.95

PERFECT FOR FATHER'S DAY

Gas Soldering Iron / Torch Kit

Everything Dad needs to solder, silver solder, braze, heatshrink, strip paint etc. Refillable with stand, extra tips, torch and cutting attachment.

$39.95

- 178mm long
TS-1112

ESD Safe Tweezers with LED Illumination

Ideal for picking up tiny objects such as components or jewels with the added benefit of a LED light to illuminate the item being handled.

- Size: 155(L) x 15(W) x 10(H)mm
TH-1761

NEW $9.95

Fluorescent Tube Adaptors T5-T8

Easily convert traditional T8 fluorescent lighting to more energy efficient T5 series tubes using these tube adaptor sets. T5 tubes output the same light level as standard T8 tubes while consuming up to 40% less power. Easy installation. See website for more details.

Light Energy Saving

Replaces 20W (2ft) Tubes with 14W T5 Tube
SL-2746 $17.95

Replaces 40W (4ft) Tubes with 28W T5 Tube
SL-2748 $19.95

NOTE: Not suitable in T8 fittings with electronic ballasts.

FROM $17.95

Handy Magnet Strip

Attach the handy magnets to walls, tables or other surfaces to hold tools, brushes, scissors, key rings or any other object that contains iron.

- 9 pieces
LM-1624

$19.95

Screwdrivers & cutter not included

Solder/ Desolder Rework Station

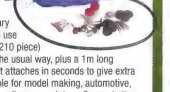
Complete solder/desolder station for production and service use. The temperature is easily adjusted in 1° increments with simple up/down buttons and the soldering/rework functions can be operated independently of each other.

- 60W ESD Safe
- Suitable for lead-free solder
- Celsius and Fahrenheit display
- Microprocessor controlled
- Power: 60W
- Size: (225(L) x 215(W) x 155(H)mm
TS-1574 ***was $369.00***

$299.00 SAVE $70

Rotary Tool Kit with Flexible Shaft

The kit consists of a powerful 32,000 RPM rotary tool that you can use with numerous (210 piece) attachments in the usual way, plus a 1m long flexible shaft that attaches in seconds to give extra versatility. Suitable for model making, automotive, workshop, art, jewellery or sculpture. See website for full kit contents.



- Power: 135W
- Size: 210(L) x 52(Dia.)mm
TD-2459

$39.95

Aluminium Attache Case

High quality all silver case, supplied with tool pallet which can be removed if not required. Padded, lockable and supplied with 2 keys.

- Size: 455(W) x 330(H) x 152(D)mm
HB-6352 ***was $59.95***

$49.95 SAVE $10

Gift Ideas for Dad

6-pce Insulated Screwdriver Set

Contains all the smaller sizes you need for working on electronic gear. They have ergonomic handles with excellent non-slip grips. Storage case included.

- 1000V rated
- Case size: 192(L) x 130(W) x 26(H)
TD-2026

$19.95

Professional Laser Distance Meter

This comprehensive measurement tool adds, subtracts and calculates area, volume and takes indirect measurements. It stores up to 20 historical records which can be used for area and volume calculations. Battery and case included.

$149.00 SAVE $20

- Range: 0.05 to 50m ±1.5mm
- Min/max distance tracking
- Laser accuracy
- Size: 110(L) x 47(W) x 28(H)mm
QM-1621 ***was $169.00***

Mini Bench Vice

This strong lightweight aluminium vice will clamp to surfaces up to 1" (25mm) thick and hold material up to 2" (50mm) thick. Great for hobby work or for repairs on the go.
TH-1764

$14.95

6" 150mm Long Nose Pliers

Made from quality tool steel with soft padded handles. They have serrated jaws so you can get a firm grip on the item you're holding.
TH-1887

$11.95

To order call 1800 022 888

All savings based on Original RRP. Limited stock on sale items. Prices valid from 24th August to 23rd September 2012.

FOR THE DAD WHO LOVES HIS CAR

Bluetooth® Hands Free Car Kit

A cost effective solution for hands free mobile phone use with built-in speaker and microphone, adjustable volume and echo cancellation for clear calls. Much cheaper than getting fined!

GIFT IDEA

- Size: 56(Dia.) x 25(H)mm

AR-3121
was $29.95

$24.95
SAVE $5

Bluetooth® Hands Free Car Kit with LCD

Fits unobtrusively to the visor and features a large LCD screen to display incoming caller ID and the voice dial function. Connects up to two phones simultaneously. USB cable & 12V car charger included.

- Size: 185(L) x 136(W) x 65(H)mm

AR-3122

$59.95

Multi-Function Circuit Tester with LCD

Designed to test the electrical system of 12/24V vehicles and sends voltage to components to test functionality without jumper wires. It also tests polarity, voltage, short/open status, lights and more.

NEW
$49.95

- Size: 240(L) x 78(H) x 40(W)mm

QM-1494

Car Video Event Recorder

This handy device is automatically activated by the built-in 3-axis G sensor that responds to a sudden change in wheel speed. It starts recording the event to an SD card (16GB stores up to 5hrs - card not included). Simply mounts onto the windscreen like a GPS unit.

FREE 2GB SD CARD (XC-4998) VALUED AT $9.95

- 120º wide-angle camera with IR LEDs
- Video resolution: 640 x 480 @ 30 fps
- Real time clock stamp
- Video output for external monitor
- Size: 92(W) x 80(H)mm

QV-3798

$199.00

Cup Holder Power Extender

Designed to fit inside a vehicles cup holder and features two way cigarette lighter sockets to free up the original socket and a USB output to charge other devices.

- Holds iPhone®/iPod®
- 2 x USB outputs
- Size: 100(H) x 70(Dia. - base) x 92(Dia. - top)mm

PS-2122

$24.95

iPhone® and cable not included

USB Car Chargers for iPad®/iPhone®/iPod®

Simply plug into the car's cigarette lighter outlet and charge your Apple® devices while you're driving. Single or double outlet models available. Both units include a USB charging cable to suit iPad®/iPhone®/iPod®.

Single Charger	MB-3657 $24.95
Double Charger	MB-3659 $29.95

NOTE: Only one of the outlets on MB-3659 is 2.1A; the other is rated for 1A (to suit an iPhone® etc).

FROM **$24.95**

4-Door Remote Controlled Central Locking Kit

Remotely lock and unlock your car doors. Install the security button to cut off the fuel pump to prevent the car being stolen. Supplied with 1 master actuator, 3 slave actuators, control relay, two remotes with batteries, kill switch, hardware and wiring loom.

- Working voltage: 9 - 16VDC
- Frequency: 433.92MHz

LR-8842

$79.95

6A Battery Charger with Trickle Charge

Suitable for both 6V and 12V car, boat, motorcycle and lawnmower batteries. Features switchable trickle and heavy duty charge rates, overload and reverse polarity protection, and tough plastic case with carry handle.

- LED charge indicators
- Heavy duty alligator clips
- Cables: 1m long

MB-3522 ***was $59.95***

$49.95
SAVE $10

FM Transmitter with Detachable MP3 Player - 2GB

Listen to your music on the MP3 player and when you jump in your car, keep on listening to that favourite track straight through the FM radio. Comes with IR remote control, USB charging cable and earphones. See website for specifications.

- 30mm LCD screen displays
- Approx 230mm long (including MP3 player)

AR-3123

$34.95

Wireless Digital Vehicle Parking Assist System

This 4 sensor reversing system features a wireless connectivity between the monitor and the sensors of up to 30 metres making it suitable for larger vehicle installations. Distances from objects are displayed on the colour LCD display as well as voice and beep alerts.

- Power: 12VDC
- Display size: 72(L) x 53(W) x 17(D)mm
- Sensor size: 23(L) x 21(Dia.)mm

LR-8874

$99.00

2 Channel Wireless Reversing Kit

Parking your car with trailer or caravan could not be easier with these reversing cameras. Each camera transmits wirelessly to the 3.5" colour monitor which mounts to the windscreen using a suction cup and plugs into the cigarette lighter socket for power. The 2.4GHz transmission provides a range of up to 80m making it suitable for a wide range of vehicle and trailer combinations including very large motor homes, trucks and caravans.

- Includes two colour cameras & LCD monitor
- 12VDC operation
- Screen size: 110(W) x 77(H) x 22(D)mm

QM-3797 ***was $249.00***

$199.00
SAVE $50

Alcohol Breath Tester

Provides far greater accuracy and reliability. Just blow in the mouthpiece for a reading in seconds. Same technology used by law enforcement for years. Spare mouthpieces (pk. 10) available separately (**QM-7303 $4.95**).

- Backlit LCD
- Alert at 0.05%
- Requires 3 x AAA batteries
- Size: 105(H) x 45(W) x 20(D)mm

QM-7302 ***was $119.00***

$99.00
SAVE $20

NOTE: Readings taken with this device are for reference only. In spite of its quality and accuracy, errors may occur due to operation or environmental conditions and we accept no liability or responsibility whatsoever for any consequences arising from the use of this device.

Automotive DMM

Features an inductive pickup for RPM measurement, dwell angle, frequency, duty cycle, data hold, relative function, backlit display and temperature, and works with engines of 2 to 10 cylinders. Probes, alligator clip probes and holster included.

- RPM x1, x10
- Size: 146(H) x 66(W) x 42(D)mm

QM-1444

$59.95

Digital Car Power Adaptor

Offers 7 different DC voltages with 3A continuous output, plus a USB charging output suitable for the latest smartphones and i-gadgets. The display provides accurate digital read outs of vehicle's battery voltage, selected output voltage and power used by the load.

- Size: 98(L) x 57(W) x 17(H)mm

MP-3673 ***was $69.95***

$49.95
SAVE $20

Jaycar ELECTRONICS
Better. More Technical.

TECHY GADGETS FOR DAD!

FREE HDMI LEAD (WV-7914) with XC-4204 PURCHASE WORTH $9.95

1000VA/700W Online Rack Mount UPS

Sometimes called a true UPS - the primary power source is the battery and utility power is the secondary power source. This design means that there is no transfer time in the event of a power failure. This UPS can be either incorporated into a standard 19" rack set up or used in a tower configuration; brackets are included for either application. The LCD tells you charging and system status.

- Rating: 700W • Supply voltage: 220 - 240VAC
- Backup time at full load: 5mins
- Output voltage: 230VAC
- Recharge time: 18 hours
- Output waveform: Sine wave
- Size: 440(W) x 350(D) x 56(H)mm

MP-5212

NEW $599.00

1080p Media Player

Easily view your collection of downloaded movies or digital pictures on your TV. Just attach your USB hard drive or thumb drive with your movies or SD card from your digital camera and start watching.

- 1080p HD Video
- HDMI, YPbPr (YUV component) & AV outputs
- Ethernet connectivity (UPnP)

XC-4204

GIFT IDEA $119.00

USB Power Bank

Features a USB charging port and lead with 3 connectors for charging all variety of smartphones, tablets and USB charged devices. The device itself can be recharged with the supplied micro USB to USB cable.

- Size: 76(L) x 33(W) x 29(D)mm

MB-3642

$34.95

Multi-Network Cable Tester

Designed to quickly test UTP/STP/Coaxial/ Modular network cables by manually or automatically scanning the wires for continuity, incorrect wiring and polarisation.

- Pin out indicator
- Requires 1 x 9V battery
- Main unit size: 104(L) x 62(W) x 26(D)mm Active Terminator: 100(L) x 30(W) x 25(D)mm

XC-5076

NOTE: Not suitable for Live circuits

$39.95

Docking Station and Dual Charger for iPad® & iPhone®/iPod®

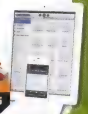
Simultaneously dock your iPad® and iPhone®/iPod®. Use as a standalone charger or as a docking station to connect your device to your computer and sync with your iTunes® account.

- Power adaptor included
- iPad® charges at 5V/2A
- iPhone®/iPod® charges at 5V/2A
- Size: 170(L) x 110(W) x 30(H)mm

WC-7719

GIFT IDEA NEW $49.95

iPad® & iPod® not included



Portable A4 Hand Scanner

Capture A4 documents or images quickly straight to Micro SD card. No PC or software required. 2 x AA batteries (not included) provides about 180 scans.

- Colour sensor • 300DPI 125cm/ 600DPI 62cm
- Supports MicroSD cards up to 32GB
- Store up to 1280 x 300DPI images
- Size: 256(L) x 30(W) x 31(H)mm

XC-4909

GIFT IDEA $99.00

FREE 2G SD CARD (XC-4998) with XC-4909 PURCHASE WORTH $9.95

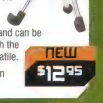
Bracket Stand for iPhone®/iPad®/Android

A convenient tripod stand for tablets and smartphones, including iPhone®, iPad® and Android devices. The middle leg of the stand can be adjusted to set the angle at which the device sits. Lightweight and versatile.

- Size: 110(H) x 43(W) x 38(D)mm

HS-9018

NEW $12.95



POWER IT UP!

Power Tower - 8 Way Powerboard

Stands vertically and has the convenience of the two built-in USB ports to charge any USB product, such as an iPhone®. Features 8 surge protected sockets, power overload protection, and when it's not in use simply store the power cord in the bottom of base. Perfect for under the desk or behind your entertainment unit.

- AC Rating - 230V, 10A, 2400W
- Power safety shutdown 10A, 250V
- Surge rating: 3150J/90,000A
- Size: 225(H) x 170(W) x 170(D)mm

MS-4023

iPhone® not included

DUE EARLY SEPTEMBER

NEW $69.95

Mains Wireless Power Monitor

With the sensor unit installed in the fuse box, household power usage data is wirelessly transmitted to the indoor display unit up to 50m away.

- Electricity usage (watts), cost and time displayed
- Suitable for single phase only
- Batteries included
- Display size: 101(H) x 80(W) x 42(D)mm Sensor size: 75(L) x 60(W) x 35(H)mm

MS-6160 *was $79.95*

$59.95 SAVE $20

Mains Laptop Power Supplies

Ideal spare or replacement power supplies for on the go or just at the office. Compatible with most notebooks on the market. Check our website for compatibility.

- Automatic power selector

40W Netbook
- 7 plugs

MP-3477

$49.95

MP-3320

70W Universal
- 16 plugs

MP-3320

$59.95

MP-3327

90W Universal Slimline
- 8 plugs

MP-3327

$79.95

120W Universal
- 13 plugs

MP-3328

$129.00

MP-3328

Briefcase Amorphous Solar Chargers

Great for keeping a car battery topped up while on holidays or in storage. Three sizes for small, medium and large cars or 4WDs. Each terminates in a cigarette lighter plug or alligator clips.

FROM $19.95 SAVE $5

12V 2W Charger ZM-9036
- Size: 304(L) x 185(W) x 17(H)mm

was $24.95 now $19.95 save $5.00

12V 4W Charger ZM-9037
- Size: 445(L) x 237(W) x 17(H)mm

was $34.95 now $29.95 save $5.00

12V 7W Charger ZM-9038
- Size: 492(L) x 335(W) x 18(H)mm

was $59.95 now $49.95 save $10.00

To order call 1800 022 888

All savings based on Original RRP. Limited stock on sale items. Prices valid from 24th August to 23rd September 2012.

FOR THE DAD WHO LOVES THE OUTDOORS

Weather Station LCD Keyring

A weather station to fit in the palm of Dad's hand. It shows forecast, temperature, humidity, time, date and moon phase. Complete with inbuilt LED torch and compass.

- Batteries included
- Size: 93(H) x 50(W) x 18(D)mm

XC-0341

$19.95

BUY 2 FOR $30 & SAVE $9.90

Deluxe Mini Weather Station

Compact weather station, altimeter, timer, alarm clock and ordinary clock. Has a nifty little handle that goes straight on to a carabiner.

- Includes 1 x CR2030 battery
- Size: 70(L) x 45(W) x 15(D)mm

XC-0358 *was $29.95*

$24.95

SAVE $5

LED Bike Light Kit

Outputs 190 lumens and has an adjustable focus beam. Mount the torch onto 25 to 31mm handlebars with the adjustable bracket or detached it and becomes a conventional torch.

- Light mode: focusing beam, flashing & continuous
- Requires 5 x AAA batteries
- Torch size: 105(L) x 32(Dia.)mm
  Tail light size: 60(L) x 35(H) x 25(D)mm

ST-3465

$29.95

BUY ST-3465 & GET 50% OFF BICYCLE TOOL KIT (TD-2176) SAVE $9.95

Bluetooth® Motorcycle Headset

Communicate wirelessly whilst riding your motorcycle. It enables you to pair two devices simultaneously, such as two mobile phones, or a mobile phone and another AR-1864, giving you an intercom between rider and pillion. IPX6 certified for use in all weather conditions.

- Large buttons
- GPS support and velcro pieces included

AR-1864 *was $99.00*

Helmet not included

$79.00

SAVE $20

Novelties Dad will LOVE!

USB Plasma Ball

As the ball becomes energised, the gases inside light up and turn into plasma. By touching the outside of the ball, you can produce amazing effects.

- Size: 130(H) x 100(W)mm

GE-4089

$19.95

LED Torch with Magnetic Head and Telescopic Neck

A pen-sized torch with super bright LEDs and magnetic head for picking up objects. Extendable to 546mm and gooseneck at the end allows light to be shone around corners, into cracks and crevices.

- Size: 165mm long to 546mm extended
- Includes 4 x LR44 batteries

ST-3463

$14.95

Economy Head Torch

For the adventurous Dad! 12 LEDs with 4 lighting modes this head torch is light, compact, very efficient on batteries and comes with an adjustable head strap.

- Requires 3 x AAA batteries

ST-3286

BUY 2 FOR $15 & SAVE $4.90

See in-store or online for our full range of head-torches and outdoor equipment.

$9.95

12V Portable Stove

Cooks, warms or reheats at up to 125°C. Deep lid design, with a case made from durable ABS plastic and carrying handles.

- Size: 265(L) x 180(W) x 155(H)mm

YS-2808

$49.95

Advanced 2W 80 Channel UHF Transceiver

A stand-alone transceiver for professional and leisure activities. 2W output provides up to 10km range. Save battery power by switching to 500mW for short-range communications. Features CTCSS, 80 channels, plus a rechargeable Li-ion battery with a plug pack charger.

- Hi/Lo power output
- Auto squelch
- Backlit LCD
- Roger tone
- Stop watch
- Size: 152(L) x 60(W) x 30(H)mm

DC-1049

NEW $99.95

Novelty Air/Water Balloon Pump

Inflate balloons with air without becoming breathless doing it yourself, or fill balloons with water for some summer fun. Includes 500 colourful balloons to get the fun started.

- Suitable for ages 3+
- Size: 330mm high

GT-3013

NEW $14.95

Dynamo Torch with Radio, Clock & Alarm

Features an AM/FM radio with alarm clock, high intensity LED torch, reading lamp and an output jack for a mobile phone charger cable (cable not included). All powered by the attached manual hand crank (dynamo) or 3 x AA batteries/external power supply (not included).

- Size: 200(W) x 130(H) x 75(D)mm

ST-3352 *was $59.95*

$49.95

SAVE $10

High Brightness Rechargeable Automotive Work Light

200 Lumen functional work light. Affix to any metallic surface via magnetic base and back. Adjust direction of light using multi-position stand. Use it like a torch or hang it off your car bonnet.

- Rechargeable Lithium battery
- 3 x 1W CREE® LEDs with optical lens for better focus
- Two hanging hooks
- Size: 280(L) x 62(W) x44(D)mm

ST-3261

NEW $59.95

Electronic Antifouling Units

The ultrasonic frequencies seriously deter marine growth that choose to use your boat as a home, reducing the frequency of slipping for messy, expensive antifouling treatment. These completely manufactured units are straight forward to install. Power is supplied by 12VDC and a low voltage cut-out feature is also included, which protects the boat's batteries from being over discharged. Each unit includes a control box (5m lead) and transducers (10m lead each), and a comprehensive installation & instruction manual. More details and specification can be found on our website.

FROM $899.00

Dual Output, suitable for vessels up to 14m (45ft)

YS-5600 $899.00

Quad Output, suitable for vessels up to 20m (65ft)

YS-5602 $1199.00

NOTE: Larger vessels can simply use multiple units. Twin hull vessels will require double the recommendations above.

Motion Activated Lolly Dispenser

A smart alternative to messy, germ-filled lolly bowls. The easy-fill top makes it simple to load in your unwrapped lollies, unsalted nuts, and gum balls.

- Hand activated
- Requires 4 x AA batteries or power adapter
- Suitable for ages 12+
- Size: 279(H) x 190(W) x 165(D)mm

GH-1182

$39.95

Yummy lollies not included

GET READY FOR THE FOOTY FINALS

Don't Miss a Minute of the Footy!

Our newest 2.4GHz Wireless Audio Video System uses the cutting-edge design in wireless digital technology to send stereo audio and video around your home. Also integrates an infrared extender which allows control of the settings from the receivers end. Supplied with power adaptors.

- IR range 30 to 57KHz
- Transmits distance up to 100m
- Size: 170(W) x 130(D)x 43(H)mm

AR-1872

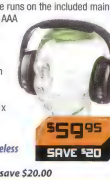
NEW $169.00

Wireless Stereo Headphones

Enjoy high-quality stereo sound from the built-in FM radio or from audio devices such as a TV, PC or Hi-Fi. Transmitter charging cradle runs on the included mains AC adaptor or requires 3 x AAA batteries. 900MHz.

- Frequency response: 22Hz - 20kHz
- Transmission range: 15m
- Cradle size: 215(W) x 68(H) x 135(D)mm
- Headphone size: 205(W) x 200(H) x 85(D)mm

AA-2071 *was $79.95*



$59.95 SAVE $20

Also available: *2.4GHz Wireless Headphones* AA-2073
was $99.00 now $79.00 save $20.00

Home Theatre Power Board

Protect Dad's home theatre and sensitive high-end gear. With surge protection, filtering and a built-in circuit breaker for 8 mains outlets, this powerboard also has telephone protection (1 input, two outputs so doubles as a splitter), data/network connection, satellite/cable TV, and TV antenna. See website for more info.

- 8-way
- 10A resettable overload circuit breaker

MS-4029 *was $79.95*

$69.95 SAVE $10

STORE RELOCATION

Tweed Heads NSW 2486
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Ph: (07) 5524 6566

WA STORES*

NOW TRADING ON SUNDAYS 11 am to 5 pm

**Except Mandurah*

Active Column Speakers

Provide excellent directivity through the three 4" full range drivers installed. Features a built-in amplifier and provides 20WRMS of power to each speaker unit. RCA inputs for audio source connection. Mains IEC leads included.

- Finished in glossy white paint
- Voltage: 240VAC
- Size: 532(H) x 113(D) x 131(W)mm

CS-2439

$299.00 TV not included

SOLD AS A PAIR

HDMI Lead with Rotating Plugs

HDMI cable with a difference: the plug on each end of the cable rotates through 180° to accommodate whatever installation challenge you have.

- 1.5m length
- HDMI 1.3 compliant

WQ-7401

BUY 2 FOR $25 & SAVE $4.90

$14.95

Aircon Universal Remote Control

A feature rich replacement for a lost or broken air-con remote. Includes temperature controls, swing, vane, fan, Celsius/Fahrenheit adjustment, sleep and more. Compatible with up to 2000 models of air conditioner.

- Backlit LCD
- Includes mountable remote cradle
- Requires 2 x AAA batteries
- Size: 165(L) x 55(W) x 25(D)mm

AR-1731

NEW $24.95

Ultra Slim LED/LCD Tilting Wall Mounts

Designed for LED/LCD TVs and allows 15° of tilt, and mounts only 19mm from the wall. Heavy duty steel construction. Mounting hardware and instructions included.

- Load capacity up to 25kg
- VESA standard complaint

FROM $39.95

For 23" - 55" LCD/LED TV Sets CW-2836 $39.95

For 40" - 65" LCD/LED TV Sets CW-2838 $49.95

VGA & R/L Audio to HDMI Scaler Converter

Converts VGA and left/right audio inputs to HDMI for use with the latest digital HDTV.

- HDMI resolution fixed to 1280x720p
- HDMI 165MHz/1.65Gbps per channel (6.75Gbps total)
- HDMI 8 bit per channel
- Size: 88(L) x 68(W) x 25.5(H)mm

AC-1617

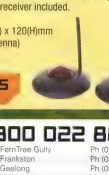
NEW $99.00

IR Remote Control Extender

Extend the range of your IR remote control up to 100m. IR commands are sent by the transmitter via 433MHz signal to the receiver in another room, then sent to the components you want to control. Mains plugpacks for transmitter and receiver included.

- Size: 100(Dia.) x 120(H)mm (including antenna)

AR-1817



$49.95

YOUR LOCAL JAYCAR STORE – Free Call Orders: 1800 022 888

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Tweed Heads (NEW WORKS)	Ph (07) 5524 6566
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Mackay	Ph (07) 4953 0611
Maroochydore	Ph (07) 5479 3511
Mermaid Beach (NEW WORKS)	Ph (07) 5526 6722
Rockhampton	Ph (07) 4926 4155
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• WESTERN AUSTRALIA

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Australia's largest exhibition of Vintage Radios:

The HRSA 30th Anniversary RadioFest

By Kevin Poulter

It's on this month in Melbourne: 22-23 September at the Springvale Town Hall. We'll see you there!

The Historical Radio Society (HRSA) was formed by a group of vintage radio enthusiasts in 1982, led by Ray Kelly, who was a formerly a PMG radio technician. The society's aims were to preserve vintage radios, plus source circuits and parts.

They could never imagine their tiny group would grow to 1,200 members, one of the largest Vintage Radio Societies in the world.

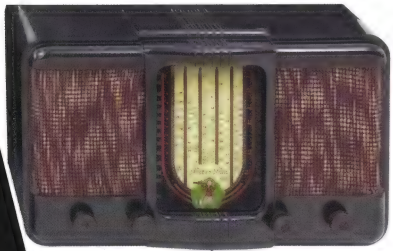
HRSA groups meet each month in major cities and regions around Australia to share and exchange information on the golden days of radio – when radio was king and the source of national plus international news, entertainment and education.

A time too, when the larger radios – and later radiograms – were the finest furniture in the home.

To attract buyers from the multitude of brands available, magnificently designed radios were manufactured, with superb mouldings in wood and Bakelite – along with creative posters, photographs and magazines.

The world's radio factories ranged from immense – even by today's standards (see the Atwater Kent story, SILICON CHIP, March 2012), to many tiny 1-3 man factories, or even based in home garages.

Production included radios for essential services such as the military and the HRSA members have just as diverse interest groups. Each member considers it's vital to preserve Australia's radio



highly collectable and much-sought-after historic radios: at left is a Peter Pan lite and alongside it, an AWA "big brother" Empire Radio.

Psst! Wanna buy a not-so-cheap radio? But what's that XBox doing there?

heritage, given it's incredibly easy for people to throw out old radios.

Then they are lost forever.

Horror stories from members remind us how fragile history can be.

Australia's largest Radio Exhibition

The aim of the Historical Radio Society of Australia (HRSA) members is to ensure everyone, now and in the future, can see vintage radios.

These are displayed at HRSA Anniversary events, (now called their RadioFest).

After a successful event in Canberra, the HRSA is celebrating their 30th Anniversary in Melbourne on September 22-23, in the huge Springvale Town Hall.

Members are coming from around Australia and the display is open to the public on Sunday 23rd.

The entire hall and adjoining rooms are booked out by the Society, to display hundreds (perhaps up to one thousand) of vintage radios, from Marconi spark radios, to the plastic radios of the 60s.

A magnificent range of vintage radios on display

Not only is the event Australia's largest radio display by far – it's a rare chance to see every conceivable type of radio – Mantel, Cathedral, Military, Battery, Spark, Crystal Set, Vibrator, Car, Console and radiograms, to name a few.

There are also related items, like a 1950s Marconi TV camera.

There will be the rarest radios, especially Marconi spark radios meticulously built by a HRSA member from photographs, drawings and circuits.

In fact you are sure to see some radios that are either the only one in existence, or extremely rare.

The Gallery will display posters of radios, advertisements and radio production along with Australian Production photographs too, including local production in the area, such as PYE Telecommunications.

Admission for HRSA members is free, or the public can visit Sunday's Exhibition and Radio Market (items for sale) for $5 each, $15 per family.

This radio has been meticulously hand-built as a close replica of Radio, originally made in London.

Silicon Chip is a sponsor of the event, with the current issue for sale. HRSA memberships and their journal Radio Waves, can also be purchased at the event.

Look, buy, sell

Now here's where it gets really exciting – many of the radios, parts, magazines, posters and more vintage radio items will be on sale. You can even purchase "new, old stock" valves (NOS).

Yes, people have stored brand new valves for generations. There are also many more pre-owned valves tested to be within their emission and other specifications.

For wider interest, including for children, be sure to see the vintage working telephone exchange, teardrop caravan surrounded by portable valve radios of the era, Radio Battery Shop, 19th century Benz car and a vintage TV camera filming and starring the visitors on a glorious Black and White screen.

HRSA membership

There are huge benefits in joining the HRSA before the event. Members have a free "access all areas" pass, so they can be part of the action all weekend, including a Class Auction, where some of the finest radios in Australia can be purchased.

The event will see even better radios and paraphernalia than offered at the regular HRSA members-only auctions and radio markets (swap-meets) held through the year.

Member-to-member sales are aimed to give newer members the opportunity to build their collection at lower prices, or all members a chance to obtain parts or a radio that has eluded them for many years.

This opportunity to obtain rare items comes with a HRSA proviso –radios purchased should not be re-sold on eBay or other commercial sales a short time thereafter. This ensures bidding is from genuine collectors in the Society only.

There will also be members-only radio repair workshops and a sit-down dinner for over 100 of Australia's most talented radio restorers and collectors, with a well-known radio personality as the speaker.

Even if you live in a regional area and cannot get to many meetings, member's benefits are many. For just $35 a year, including a colour magazine every quarter, members can order any of the Society's 20,000 tested valves, ask for a circuit for almost all known Australian radios, obtain technical advice and data sheets, information on all types of component and radio restoration, mateship with fellow radio people and a "Yellow Pages" market newsletter where members can advertise at no charge for items, either wanted, to sell or to swap.

Most of Australia's vintage radios are in HRSA hands

Collectively it's estimated the HRSA members have over 30,000 radios and radio-related items. There's a vast array of member's specialities which can help you in your interest, like military radios, transistor radios and much more.

Some members focus on restoring timber cabinet or Bakelite radios. A few who repair broken Bakelite are masters of the craft, taking up to 30 pieces or more and joining them invisibly. My speciality is collecting and restoring radio advertisements and photographs.

The website www.ozradios.com has details and a link to the HRSA site, where you can apply for membership. (The application form asks for a member to nominate you, however if you don't know anyone in the HRSA, just leave that blank.) SC

A range of novelty transistor radios will be for sale, such as those built into "piano" cases, cartoon characters or even mini jukeboxes!

SERVICEMAN'S LOG

Outsmarted & frustrated by smartphones

Dave Thompson*

Servicing here in Christchurch is really in the doldrums but my recent attempts to diversify have hardly been a rip-roaring success. One thing I have learned: stay away from no-name smartphones.

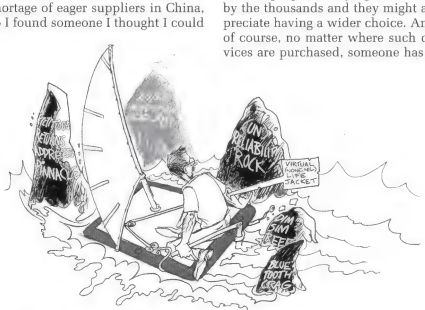
Regular readers of this column will know that times are tough here in Christchurch. Not only is the city literally disappearing as demolitions reach high gear but many residents have also left for safer havens. Life for those staying goes on though and the frequent aftershocks don't bother us as much as the noise and vibration from nearby buildings succumbing to the wrecking ball all day long.

Almost every service-related business in this city has been adversely affected. As a result, many are now looking for ways to diversify and offer more products and services to the people who have remained.

In my case, with technology rapidly moving towards mobile computing using smartphones and tablets, I decided to see if I could expand my business into that area. There's no shortage of eager suppliers in China, so I found someone I thought I could form a business relationship with and purchased five appealing, mid-priced smartphones from them.

The feature list of these handsets was impressive. For starters, all were dual-SIM (making it easy to combine work and personal numbers on the same phone). In addition, all ran Android, boasted generous in-built storage, WiFi, Bluetooth, large capacitive touchscreens, reasonably "specced" processors, GPS, analog TV and a raft of other features, some not found in even the top-shelf models sold locally.

Along with the phones I ordered a couple of entry-level 7-inch Android tablets, which boasted built-in WiFi, 3G and other similar capabilities to the smartphones. All going well, I figured I could sell and support these devices, adding another thread to my business; after all, people are buying these things by the thousands and they might appreciate having a wider choice. And, of course, no matter where such devices are purchased, someone has to fix faulty devices once the warranties run out and I figured that it may as well be me.



~UNFORTUNATELY, IT WASN'T TO BE ALL SMOOTH SAILING...

Well, that was the theory anyway. Unfortunately, it wasn't to be all smooth sailing.

When the hardware arrived, I was impressed with the build quality and appearance. They all worked well too and while not as blazingly fast as, say, the latest Samsung Galaxy, iPhone or tablets, they were still quite usable. I started using one of the 4-inch smartphones as my everyday phone and found the dual-SIM feature extremely useful. Everyone who saw it wanted one, especially when they heard the price, which worked out to be about half that of the better-known branded models.

As this was what I'd envisaged, I duly ordered a shipment and delivered them to happy customers. All came with two batteries, a car charger, a wall charger and a USB cable for connection to a PC (both for charging and connectivity).

Problems

Unfortunately, it wasn't long before the problems started. One phone wouldn't deliver SMS messages consistently. Another dropped SIM detection every few hours and had to be restarted to restore functionality. And one frequently froze and could only be restarted by temporarily removing the battery.

Out of the first batch of six I supplied, four came back faulty within weeks. My own phone, by now a testbed for every app and utility I could download for it, was running well – fingers crossed. I told the clients I'd replace their units under warranty but the gloss was already fading from my grand designs.

I duly notified the supplier and asked for his physical mailing address so I could return the phones for warranty repair or replacement. He provided it and I sent the package but it never arrived and it was only after

several months of hassles that they were finally discovered sitting in a Chinese dead-letter office with a "no such address" sticker affixed. They eventually came back – at my considerable cost – and are currently sitting on a workbench while my emails to the supplier go unanswered.

At this stage, it looks like they are likely to stay there. In the meantime, I've had to refund those clients affected as well as take a reputation hit; not a good thing for any business, especially around here these days. On reflection I should have been more cautious but hindsight is always 20/20.

To add insult to injury, my own phone eventually failed when the screen gave out. A direct replacement screen was available but when I swapped it over (which wasn't easy), it wouldn't display all colours and the supplier claimed I'd need to flash a new ROM version to the phone to get it working properly.

It all seemed so dodgy; if a supplier advertises a direct replacement part, even down to the same part number, I'd expect it to "plug and go", without having to do handstands to make it work.

As can be imagined, I wasn't happy. The worst part about the whole episode was the lost business opportunities but if I cannot guarantee a good product, a regular supply chain and full warranty service, I just cannot sell in good faith.

Cowboy operators running temporary stalls in malls and markets might (and do) get away with it but this sort of arrangement doesn't cut it with a reputable service provider who values repeat business.

Taking a different tack

Anyway, with that experience under my belt, I decided there was still potential but this time I decided to look at the vast brand-name phone and tablet market. Many Asian merchants sell brand-name devices and while some may be last year's model, they are still excellent devices with all the trimmings and quality customers expect. The purchase price is generally about a third to a half of what they sold for the previous year on the local market, so the value and brand recognition is still there.

By the way, these are not to be confused with "counterfeit" phones, all of which vary considerably in quality ranging from poor to appalling. These are to be avoided like the plague.

This time, to test the supplier, I purchased a Samsung Galaxy Captivate, a phone which was highly regarded at the time of its release. It arrived quickly and was everything I expected; beautifully made, with a Gorilla-glass protected 4-inch screen. It also zipped along very nicely, making it a significant step above the "clone" phones I'd purchased before.

One thing against this unit and most brand-name phones is that they don't usually boast the extensive feature set and in-the-box extras of those cheaper phones, ie, the spare batteries, multiple chargers, built-in TV, multi-SIM capability and all the other goodies I'd been spoilt with in my phone. Many are also built for a client company, in my case American telco AT&T. This means that not only does my Captivate sport prominent AT&T logos, it is also loaded up with AT&T-proprietary apps and other software that is redundant on other networks.

Fortunately, it's easy enough to uninstall and/or freeze those apps from running and this is exactly what I did and soon my new Samsung was bloatfree and running sweetly.

Being a genuine Samsung phone, it can be registered with Samsung and will talk to the proprietary Kies software, which can be downloaded from Samsung's website. Once installed to a computer, you simply connect the phone using the supplied USB/charging cable and the Kies program interrogates the phone and offers a range of functions and services, including any available updates and patches.

When I connected my phone, the

Items Covered This Month

- Outsmarted by smartphones
- Ariston KS2050A dishwasher
- Mitsubishi SL4SU LCD projector
- The VT Commodore that wouldn't start

**Dave Thompson, runs PC Anytime in Christchurch, NZ.*

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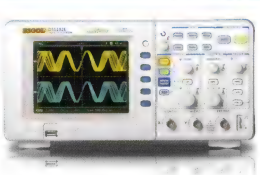

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software indicated that an update from Android Eclair to a later version (Froyo) was ready to download and install. I hit OK and when the update process began, was warned not to turn the phone off (or my computer). Worryingly, a message also stated that if anything went wrong, I should follow the instructions and click the Emergency Recovery button.

Admittedly, that was a little concerning but all seemed to go well. The process looked like it would take a while so I hit the web to read up about it (I know, I should have done all this beforehand but in my defence, I am a bloke and a tech and, well . . . you know why).

Anyway, I learned that the update process should take about 10 minutes, so after an hour I was starting to fret. The progress bar had stopped at 61% which, as Daffy Duck would say, was a revolting development. I couldn't find any realistic advice among the mass of information on the web, so I decided to pull the pin and see what happened. I restarted the phone and waited; nothing. I pulled the phone's battery and restarted the computer as well. The phone still wouldn't light up.

Great; I now had what the phone nerds call a "soft bricked" phone.

There was still hope; I reconnected the phone and followed the instructions to put the handset into "download" mode, which is a special recovery mode for when things go wrong. It went into that OK so I had faith everything would be fine. I ran the software again and as promised was offered Emergency Recovery mode.

Theoretically, this would flash the previously saved Android Eclair version back to the phone and all would be well. I clicked "Go" and watched as the progress bar indicated the restoration process. However, it again gagged somewhere in the middle and after another hour's fretting, I accepted that it was going nowhere and pulled the pin. Now my phone wouldn't even enter download mode, nor would the computer detect it when connected to the USB cable.

It was, in the words of phone geeks, "hard-bricked", meaning normal recovery was impossible.

Unbricking ain't easy

By now feeling quite frustrated and annoyed, I hit the web to find out what (if anything) could be done. The options appeared to be limited. First, if the phone was under warranty, it could normally be returned for a replacement. However, my vendor didn't want to know about failed updates so the only other possible option was to send it to some guy in the USA who "unbricked" phones for a fixed fee plus shipping. Neither option was going to work for me.

I did have an idea though. While looking for answers, the term "JTAG" kept popping up as an almost magical way of recovering disastrously-lost phones. It seemed there was a commercially-available box one could purchase and along with the software available from the support site, miracles could be performed. That sounded much better, so in true "geek-tech" style I located and purchased one of the JTAG boxes, downloaded the software and set about undoing what had gone wrong.

For those unaware, JTAG is a technology used to test and inject ROM images directly into programmable chips. At the factory, they don't have to mess about installing Android on each and every phone. Instead, they simply plug the handset's motherboard into a JTAG programmer and "flash" the image directly into the chipset. Further along the assembly line, a tester inserts a battery and powers up the phone. All being well, the factory-installed image should boot and will include everything the customer requires, in my case Android Eclair with all the AT&T apps.

With that in mind, all I needed to do was download the correct image from the website, connect the programming box to the phone and hit the button to restore it to factory default. It all sounded too good to be true but the blokes who work such magic commercially on the web assure us (complete with YouTube videos) that this can and is being done.

I had everything I needed so the only remaining problem was connecting the box to the phone. From what I can gather, the JTAG expansion port on the majority of phones has a built-in header, so all that is required is a matching adapter to go from the phone to the programmer. On my phone though, Samsung decided to not include a header, so all that's evident is a tiny set of surface-mount PCB pads that the header would have normally been soldered to. And when I say tiny, I mean tiny; the 12 pads (6 x 2 DIL) are each less than 1mm long and are just 0.2mm wide, with a pitch of 0.4mm.

That pretty much precludes using any of the soldering gear I possess and I have some pretty good tools in that department. Under the strong magnifying glass I needed to even see the pads on the board clearly, my finest needle-point soldering tips looked like baseball bats and dwarfed the points I wanted to solder. The professionals on the forums claimed the Captivate

The VT Commodore That Wouldn't Start

Back in the April 2012 issue, G. C. of Toormina, NSW described a frustrating experience with a VS Commodore that had an intermittent engine cut-out problem. This time, he tangles with a VT Commodore. Here's the story . . .

Just recently, our nephew (Chris) came to board with us for a short period. He has a 2000 VT Commodore which had been reliable but then, suddenly, it started giving him grief.

It all started with a phone call from Chris saying that he was stuck in town and couldn't start the car. He thought he needed a jump start. I asked if he was in the NRMA but he wasn't due to being a cash-strapped student so I grabbed the jump starter pack and headed into town.

We popped the bonnet and I asked Chris to try to start the car. I could hear the starter relay clicking as the key was turned but that was all. The starter motor was dead quiet. I pulled out the starter relay and bridged the power contacts and could hear the starter solenoid clicking but that was all.

We had to jack up the side of the car and get under it to get to the starter. I then used a 12V test lamp to check that power was getting to the solenoid terminal and that the solenoid was feeding power to starter. This all checked out but there was still no action from the starter itself.

My conclusion was that it was probably worn brushes, so I tapped the starter with a hammer and this time it burst into life. Chris then followed me home and we subsequently ran the car up onto ramps and replaced the starter motor with a reconditioned unit. All went well and the car then started reliably – for about two weeks.

I then received another phone call from Chris saying that he was stranded again, this time in a car park near the beach. He was understandably a bit huffy and was wondering what sort of warranty applied to the replacement starter motor.

Anyway, off I went again and we went through the same troubleshooting procedure. This time, the starter relay wasn't operating when the key was turned. With the aid of the test lamp, we found that +12V was appearing on one side of the relay coil when the key was turned but there was no circuit to earth on the other side of the coil. A quick look at the circuit diagram (I have a manual for the VS Commodore) revealed that this circuit is enabled by the inhibitor switch for the automatic transmission. This switch is in series with the remote key receiver (engine immobiliser).

I suspected the inhibitor switch, so we switched the ignition on and bridged the starter relay contacts to see if we could get it started. The engine cranked beautifully but the car refused to start. A quick check then revealed spark at the spark plugs but no 12V pulses to the fuel injectors.

The wiring diagram showed that the 0V line for the injectors came from the ECU, so it appeared that the immobiliser was disabling this output. Chris then mentioned that the remote key had been sluggish recently and wouldn't always work.

So that was it but we were still stuck at the beach. What's more, it was getting dark, it was cold and it had started raining (of course). We didn't feel happy about leaving the car there overnight, so we decided to tow it the short distance home. What a nightmare – the tow rope somehow detached itself while we were crossing a roundabout and although we had all our hazard lights on, other drivers were zooming past at speed, yelling abuse while we reattached the rope in the rain.

It's incidents like that that make you realise just how many boneheads there are out there on the road.

The next day, Chris took the key down to the local Mister Minit. They cracked open the case and found that the circuit board and battery contacts were heavily corroded. Even so, they managed to extract the code and cut a new key.

The technician said that he was sure that it should work but there were about seven possible code positions to try so Chris went back and forth on his pushbike about five times before they finally cracked the correct code position.

I arrived home to find Chris trying the key out but when it was turned to the start position, the starter relay oscillated at about 5Hz but there was no sound from the starter. So what sort of whacko fault did we have now? By this time, it was getting dark again so we decided to leave it until the next morning.

The next day, as I was getting some test gear ready, the answer to the problem suddenly came to me. Along with out attempts at cranking, we had also used the headlights and hazard lights while towing, so the battery would have to be pretty flat by now. Just to prove it, I check the open circuit battery voltage and this measured 11.9V. However, when I bridged the stater relay contacts, the battery voltage fell to just 1.8V!

I replaced the starter relay and jump-started the car and that was it. Once the battery had recharged, everything was back to normal but what a battle.

So why did the starter relay oscillate? Well, when the key was turned to the start position, the relay pulled in and energised the starter motor which immediately caused the battery voltage to collapse (due to it being flat). This then caused the relay to drop out and switch off the starter motor, at which point the battery voltage rose again and pulled in the relay and so the cycle repeated while ever the key was held in the start position.

was the hardest phone to work with, not because it was complicated but because of the lack of a JTAG connector. Just my luck . . .

Well, as any red-blooded tech would do, I had to at least have a go at it so I set about soldering some 0.14mm wires onto the pads, an operation which was only partially successful. While I could solder to the outside pads without problems and one or two each side of the inner pads, as soon as I got near the remaining pads the heat loosened any adjacent wires as well. After persevering for a while, I was eventually forced to concede defeat because I didn't want to risk damaging the pads any more than I had.

Dejected but not beaten, I then decided that adding a socket/header to the board would be the answer.

There was room for one and a quick review of the forums revealed others had had the same idea and had even posted part numbers for Molex and Panasonic headers. I hit the web and checked availability but nobody in New Zealand handled such things.

No problem, I had purchased from overseas suppliers before. I found the parts at a well-known component supplier and went through the check-out procedure, stopping only when I discovered that the cost of shipping the tiny 87-cent item would be a staggering $US50! This couldn't possibly be correct but after several emails back and forth to various suppliers, that is all they could offer.

How can any company in their right mind charge $50 bucks for a $1 item that could easily be slipped into a padded envelope and sent for the price of an airmail stamp? I smelled a rat and told them so but that didn't help me get any further.

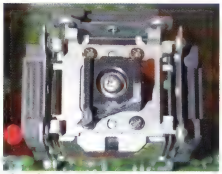
Finally, after much staring at the board and contemplating, I decided the only other way forward was to make my own jig. A friend of mine owns an engraving/cutting laser and after determining he could cut down to 0.05mm, I asked him to design and make a jig that I could clamp onto the board. Not only would this be better than a header, if anyone else wanted their Captivate unbricked, I'd already have a jig for it.

That jig is being made as I write; I'll let you know how we designed it and the final results in a future story!

Ariston KS2050A dishwasher

My next story comes from J. C. of Moonbi, NSW and concerns an Ariston KS2050A dishwasher. Here's what happened . . .

The problem with our dishwasher started when my wife decided to wash numerous glass bottles that she was going to use in a glass bottle wall. Her aim in using the dishwasher was to ensure that the labels on the bottles would come off easily! Well they did, causing the filter to clog and the dishwasher water to overflow into the drip tray underneath the machine.



This close-up view shows the broken bracket on the LCD module inside the Mitsubishi projector.

Fortunately, a polystyrene float in the drip tray switches off the machine when an overflow occurs.

Cleaning out the filter and draining the drip tray soon had the dishwasher going again. But that wasn't to be the end of the story. The dishwasher operated for several weeks until one night it tripped out the RCD (residual current detector) located in the fusebox.

Removing the back and running some basic checks soon revealed that the motor had developed leakage to earth. There was no need for a high-voltage test – the leakage measured 500kΩ to earth with a multimeter on the ohms range! Unfortunately, the wash motor sits just above the bottom of the overflow tray and so the lower portion of the motor windings are exposed to the water when an overflow occurs.

This meant that the motor windings had been in contact with corrosive detergent during the previous overflow incident. Sure enough, an inspection of the motor revealed spots on the windings that were devoid of insulation. Add moisture to the area and there is leakage to earth.

The windings were cleaned using CRC contact cleaner and thoroughly dried with a hot-air gun. Once that procedure had been completed, the leakage resistance to earth increased to above 30MΩ. The windings were then protected with an oil-based varnish painted on with an artist's brush.

It could be argued that a more suitable varnish should have been used, such as that used by transformer manufacturers. However, living in the bush means using what's available from the shed and for the time being, the dishwasher repair has been successful.

Mitsubishi LCD projector

My next job involved a Mitsubishi SL4SU LCD projector. It's used at our church several times each week to project the hymns onto a screen.

Recently, however, after setting it up, I found that I was unable to focus an image on the screen. A sheepish admission by one person then revealed what had happened. The projector had been dropped and something was now amiss inside, possibly a misaligned lens assembly, LCD panel or lamp.

As it turned out, the bracket that held the LCD module in place had sheared off, leaving the module to dangle on its multi-way flexible cabling. However, rather than buying a complete new plastic assembly that holds the lens, LCD bracket and projector lamp, I opted to take a cheaper approach. This involved gluing the bracket back in place using JB Weld 2-part epoxy. This epoxy is rated for high temperatures and will stick to most plastics.

As a result, the broken bracket was removed from the LCD module and glued back in place, making sure it was correctly positioned as any misalignment would affect the focussing on the screen. The main problem was that with the bracket glued back on, the only way to reassemble the unit was to attach the LCD module to the bracket after first disconnecting three very fragile multi-way flexible cables.

To avoid doing this, I drilled a hole in the underside of the projector to allow access to the securing screw. That way, the LCD module could remain connected to its multi-way cabling while it was inserted into position and secured from the underside. The screw hole was then sealed using a plastic plug, as normally used to retain ICs inside a tube. SC

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column? If so, why not send those stories in to us?

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Digital Sound Effects Module

This inexpensive, compact module can play back up to eight different sound effects, lasting a total of 60 seconds or more. It's powered from a lithium cell or from a low-voltage AC or DC supply and can be used with model railway layouts or any other application requiring sound effects.

By NICHOLAS VINEN

THIS LITTLE MODULE is quite simple but we've packed a host of features into it. You can upload a variety of sounds from a computer via its USB port and it will then play back the sounds when triggered. It's small enough to be hidden away inside a vehicle, model or wherever and it can be triggered by a microswitch, reed switch, pushbutton, sound or light detector, etc.

The most obvious use is to hide it inside a model car or train, to produce an engine sound and a horn or whistle effect. Or you could build it into a door to play back a sound each time it's opened. You could even hook it up to a pet door so that it plays a sound to let you know when your pet enters or leaves the house.

Alternatively, you could fit it with a pushbutton for sound effects while playing a game or have it triggered whenever equipment is used or the fridge door is opened. In fact, the possibilities are endless.

In operation, the unit drives an 8-ohm speaker and if the speaker is properly baffled and efficient enough, the playback volume level can be quite loud (more so with an AC/DC supply than a button cell). The playback time can be up to 60 seconds or more, depending on the sound quality used.

The module has two inputs to trigger different sets of sound effects and each trigger can be assigned to any set of the eight possible sound effect slots. When triggered, it can either randomly pick one sound from the selected set or you can have it cycle through them in sequence.

To keep the unit small and the cost low, it uses virtually all SMDs (surface mount devices). We've chosen the easiest SMDs to solder so that just about anyone can build it, given some patience. The circuit is based around two ICs, a PIC microcontroller and an LM4819 low-power audio amplifier. Up to 108KB of the PIC's internal flash memory can be used for sound storage but if that isn't enough, it can be expanded to over 1MB (more on this later).

PWM sound generation

We initially considered using a PIC microcontroller with an inbuilt DAC (digital-to-analog converter) for sound playback. Unfortunately, few PICs contain an audio DAC and those that do require a regulated supply of 2.7-3.3V. This isn't really suitable for use with a lithium cell as they can drop below 2.7V under load or if a bit flat.

Rather than add the complexity of a boost regulator to maintain the voltage, we decided to use a standard PIC with two high-speed PWM outputs. These are used to drive low-pass filters, so that we effectively build our own simple DAC. In practice, this works quite well and gives performance comparable to a dedicated 10-bit or 12-bit DAC, with quite an acceptable level of distortion – typically less than 0.2%.

Block diagram Fig.1 shows the general arrangement. IC1 produces two PWM waveforms, each with a duty cycle variable from 0-100% in 64 steps (2^6). The output from pin 7 (RP2/PWM0) is determined by the six most significant bits of the 12-bit sampled waveform being played back, while pin 2 (RP0/PWM1) has a duty cycle based on the six least significant bits. This second output is used to provide smaller output voltage steps for better resolution.

These two square waves each pass through low-pass RC filters, to remove most of the high-frequency harmonics and produce voltages which are proportional to the input duty cycles. The 34kHz -3dB roll-off point ensures that there is little attenuation of audible frequencies.

After filtering, the signals are mixed with a ratio of 64:1, to reconstruct the 12-bit digitally-sampled voltage level. Refer to the panel later in this article (Using PWM To Reproduce PCM Audio) for a detailed explanation of how the two 6-bit PWM outputs are combined to give the equivalent of a 12-bit output.

We chose six bits per output for

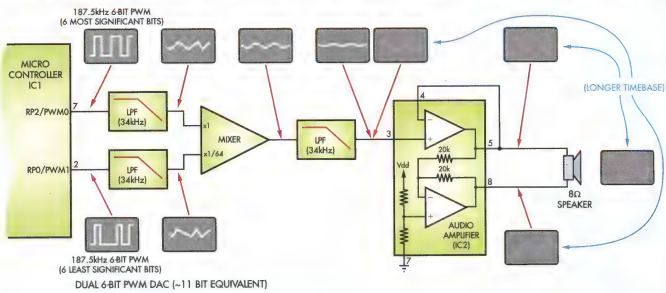

Fig.1: block diagram of the Sound Effects Generator Module showing how the PIC micro reproduces the audio. IC1 generates two PWM square waves based on stored audio data and these signals fed through low-pass filters before being mixed with a 64:1 ratio. The output of the mixer is filtered further and then passed to IC2, a low-power audio amplifier which drives the 8Ω speaker in bridge mode.

two reasons: (1) a total of 12 bits gives a good compromise between the memory required to store an audio file and the resulting playback quality; and (2) this allows us to have a PWM frequency well above the -3dB point of the required low-pass filters, so that the latter are reasonably effective.

The output from the mixer passes through another low-pass RC filter to further remove switching noise and is then fed to the non-inverting input of audio amplifier IC2. As shown, this stage drives the speaker in bridge mode. This not only maximises the audio output power (important given the low supply voltage of ~3V) but also avoids the need for a large DC-blocking output capacitor.

IC2 operates with a gain of +1 for the non-inverting output and a gain of -1 for the inverting output, giving an overall gain of 2. It's able to deliver about 100mW to the speaker, which produces quite a reasonable volume if the speaker is efficient. In practice, the available power is limited by the lithium cell.

Fig.2(a) shows a scope grab of the audio output when reproducing a sinewave. It's zoomed in far enough to show the remnants of the high-frequency PWM signal but you can also see the curved sinewave shape. When we change the scope's time base to "zoom out", we see from Fig.2(b) that the waveform is quite smooth (ignoring supersonic frequencies).

Table 1: Playback Time vs Sample Rate & Bit Depth

Sampling Rate & Bit Depth	No Flash Chips	One Flash Chip	Two Flash Chips
8kHz, 8-bit	14s	80s	125s
11.025kHz, 8-bit	10s	58s	105s
8kHz, 12-bit	9.5s	53s	97s
11.025kHz, 12-bit	7s	38s	70s
22.05kHz, 12-bit	3.5s	19s	35s
32kHz, 12-bit	2.5s	13s	24s
44.1kHz, 12-bit	1.5s	9.5s	17.5s
48kHz, 12-bit	1.5s	8.5s	16s

Interpolation

While the PWM outputs operate at around 187.5kHz, the audio sampling rate is a lot lower. If we simply changed the PWM duty cycles at the sampling rate of the audio file being replayed (eg, 11,025Hz), the output would have visible steps as shown in Figs.2(c) & 2(d).

This would result in extra harmonic content in the audio output which would sound quite bad, especially at lower sampling rates due to the larger effective step size. In fact, the audio produced using this technique sounds rather "crackly" – not good!

The simplest solution is linear interpolation. This involves changing the PWM cycle a little for each pulse, for the same total change over time but in smaller increments. In fact, Figs.2(a) & 2(b) show the identical waveform to Figs.2(c) & 2(d) but the former have the linear interpolation enabled. As you can see, the resulting waveform is much smoother and it sounds a lot better too.

This interpolation requires a lot more processing in the PIC. Each time a new sample value is loaded, it must calculate the required slope and given the low PWM resolution (six bits), this is often going to be a fractional value so we need to do some fractional maths to generate a smooth ramp.

The PIC18F27J53 is (just) powerful enough to do this with some carefully written code. With a 187.5kHz PWM

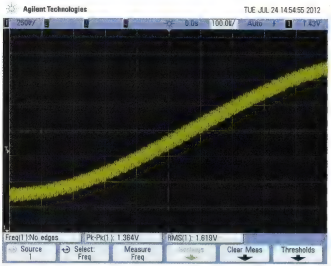

Fig.2(a): a close up of the audio output from the module (output of IC2), showing the residual PWM signal that isn't filtered out, plus the smoothly varying level of the sinewave which is being played back.

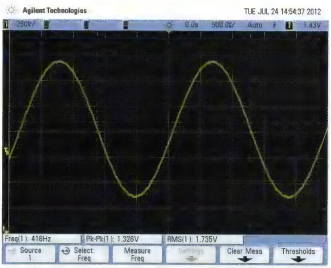

Fig.2(b): the same sinewave signal as Fig.2(a) but with a longer timebase. The low-pass filtering of the scope's input circuitry has rendered the switching residuals invisible, leaving just the smoothly varying output.

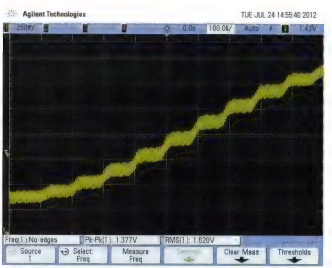

Fig.2(c): the same sinewave (11.025kHz sampling rate) being played back without the linear interpolation code active. The resulting steps cause audible artefacts, especially with lower sampling rates.

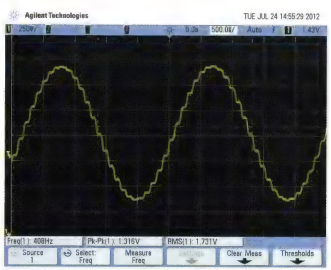

Fig.2(d): another view of the non-interpolated sinewave with a longer time base, clearly showing the steps which result from the limited time resolution available at low sampling rates.

update rate and a maximum instruction clock rate of 12MHz, we have just 12M/187.5k = 64 instructions to perform these calculations. In the end, we were able to make the code fast enough, using an 8-bit fractional sample-position counter and a hand-optimised 8 x 12-bit multiply/scale function to integrate the computed delta (ramp) value over time.

Circuit description

Now take a look at Fig.3, the complete circuit diagram. The three low-pass filters and mixer shown in Fig.1 are implemented using three resistors (two 10kΩ & one 620kΩ) and two 470pF capacitors. This is possible because the two first-stage low-pass filters and the mixer are combined. You can essentially think of it as two low-pass RC filters with a common capacitor.

In addition, the different resistor values effectively form an attenuator between the two PWM outputs, to give the correct (approximate) mixing ratio.

The relatively small capacitor value (470pF) was chosen to minimise distortion due to loading on the microcontroller outputs, which have limited current capability. The second low-pass filter is similar to the first and is connected between the mixing node (ie, the junction of the 10kΩ and 620kΩ resistors) and the non-inverting input (pin 3) of amplifier IC2.

In this configuration, IC2 only needs two additional components to operate: a 1µF supply bypass capacitor and a 10nF capacitor to filter its internal half-supply voltage generator. This latter capacitor also determines how long it takes to go into and out of sleep mode, which is used to minimise power consumption when no sound is being played. We want to play back sounds immediately when triggered, so the 10nF capacitor gives a turn-on time of just 10ms.

Audio amplifier IC2 drives the speaker in bridge mode via CON4. The circuit is DC-coupled so IC1 is programmed to deliver an average

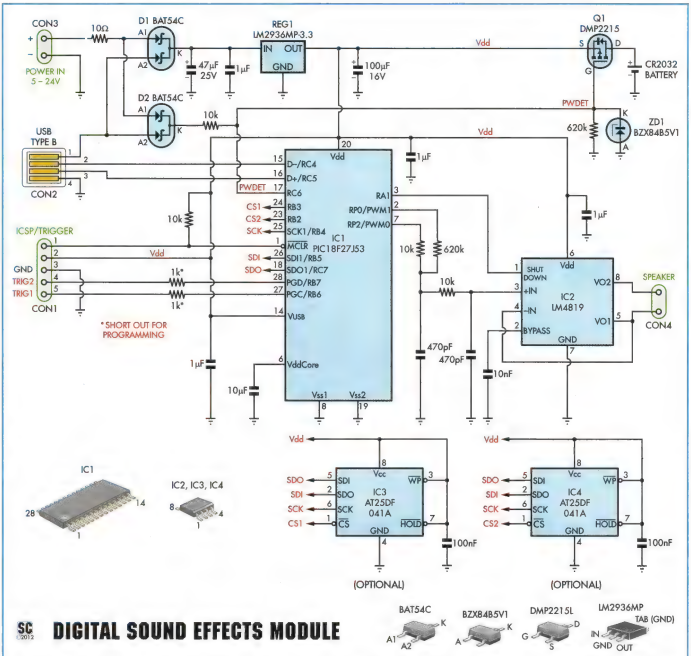

Fig.3: complete circuit of the Sound Effects Generator. IC1 generates the PWM waveforms which are filtered and then passed to audio amplifier IC2. IC3 and IC4 are optional flash memory chips for more storage space and these are controlled using a 5-wire serial bus. REG1 provides a regulated 3.3V rail when the unit is plugged into a USB port or is running from an external supply; the rest of the time, it runs off a CR2032 lithium cell. Sounds are triggered by pulling pins 4 or 5 of CON1 low and CON1 can also be used to program IC1 with an in-circuit serial programmer.

modulated output of 50% to prevent a large DC voltage from appearing across the speaker.

More memory

The firmware occupies 20KB of IC1's 128KB internal flash memory, leaving 108KB available for sound storage. This will be sufficient for some applications but if you want multiple sound effects or longer sounds, you will need more space than this.

In practice, the total flash memory can be expanded to either 620KB or 1132KB by adding one or two low-cost serial flash chips – IC3 and IC4. These each store 4Mbit (512KB) of data. IC1 automatically detects whether either or both chips are installed at power-up.

Table 1 shows the total playback time available with various combinations of IC3 and IC4 installed. IC1 communicates with the flash chips using a 3-wire SPI (serial peripheral interface) bus plus two chip-select lines – CS1 and CS2.

The specified flash chips (AT25DF041A-SSHF) were chosen for their wide operating voltage range (2.3-3.6V) and low power consumption. IC1's minimum operating voltage is 2.15V but in practice, we expect that all the ICs will run down to about 2V. The supply voltage for IC3 and IC4 is critical during erase and write operations, during which time they

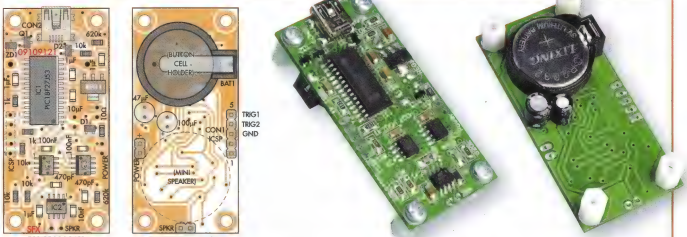

Fig.4: the SMD parts all mount on the top side of the PCB while the through-hole parts, including the cell holder, are mounted on the bottom. CON1 is a friction-fit for programming but can be soldered in to connect the trigger inputs if you don't want to solder wires direct to the PCB. Note that there is room for a small speaker to be taped to the bottom of the PCB but an off-board baffled speaker will give better results.

run from a regulated 3.3V rail derived from an external PC's USB port, via D1 and REG1.

Sleep mode

When the module is not plugged into a USB port and not playing any sounds, IC1 goes into sleep mode to save power and the whole circuit typically draws less than 10µA from the CR2032 cell. If IC3 or IC4 are installed, they are placed in "Deep Power-down" mode which, according to the data sheet, gives them a typical current consumption of 15µA each.

You would expect then that installing IC3 and/or IC4 would reduce the standby cell life substantially. However, we measured the actual sleep current for IC3 and IC4 at about 2µA each. This likely reflects manufacturing process improvements since the AT25DF041A data sheet was written and we expect most constructors will find that installing these chips has little effect on cell life.

During playback, IC3 and IC4's operating current is negligible compared to that of IC1 and IC2, due to the low data rate (72kbits/s maximum).

USB interface

The PIC's USB interface is used to transfer sound data for later playback. It's also used to configure the various trigger options. The only external component required for the PIC to communicate via USB is the mini-B type connector (CON2). The necessary USB impedance-matching and pull-up resistors for the D+ and D- communication lines (pins 16 & 15) are inside IC1.

In operation, the PIC monitors the USB V_{CC} line, to determine when the unit is plugged in. This is necessary so that the internal USB module can be turned off at other times to save power. The method used will be explained shortly.

Power supply

When a CR2032 3V lithium cell is installed, it powers all the ICs via Mosfet Q1, which provides reverse polarity protection. Q1 is a P-channel type with its gate tied to ground via a 620kΩ resistor, so that it is switched on by default. However, if the cell is somehow inserted backwards, its gate will instead go positive compared to its source. In that case, Q1 switches off and its internal body diode is reverse biased, so no current can flow.

Conversely, when it's on, Q1 has a very low on-resistance (<0.2Ω). As a result, there is very little voltage drop across it, given the low current drain from the battery (<50mA).

As stated, the circuit can also be powered via the USB port or from an external DC or AC supply. In these cases, the 3.3V supply for IC1-IC4 comes from REG1, an LM2936 low-dropout linear regulator. This is especially important for USB communications, as IC1 requires a supply rail that's close to 3.3V for proper USB operation.

When an external supply is present and the LM2936 is powering the ICs, its output voltage will typically be above the cell's voltage (nominally 3V). As a result, we need to prevent it from charging the cell, which could damage it.

This function is also performed by Q1. The external supply voltage pulls Q1's gate high via dual Schottky diode D2 and a 10kΩ resistor. One half of this diode conducts if an external USB supply is connected, while the other half conducts if an external supply is fed in via CON3. As a result, Q1 is switched off and no current can flow into the cell (since Q1's internal body diode is also reverse biased).

Note that dual-diode D2 is necessary so that you can't accidentally feed power from CON3 into the computer's USB port (if connected).

Zener diode ZD1 protects both Q1 and pin 17 of IC1 from damage should the external supply be above 5.5V. Pin 17 of IC1 is used to detect when external power is applied, to enable the USB transceiver (this pin is 5.5V-tolerant and so can be used for this task). The software sets this pin as an interrupt source, so it can wake the micro when the USB interface is connected.

DC/AC supply

The external supply can be either 5-24V DC or 5-24V p-p (peak-to-peak) AC and is fed in via CON3. This suits many applications, including a model railway system with DCC, which uses a 15-22V AC square wave. For AC, one half of dual-Schottky diode D1 rectifies the supply voltage while for DC,

this diode provides reverse polarity protection.

A 47µF 25V electrolytic capacitor filters the resulting supply rail while a 10Ω series resistor limits the in-rush current when power is first applied. This prevents D1 from burning out when the unit is first powered up. As with USB power, REG1 then provides the 3.3V supply for the ICs.

REG1 can pass up to 50mA, which gives an instantaneous dissipation of around 1W with a 24V input. That would be too high if it were sustained but in practice, power is drawn in bursts by the audio amplifier. This lowers the average dissipation to an acceptable level.

Trigger inputs

CON1 serves both as an ICSP (in-circuit serial programming) header for IC1 and as the trigger input connector. For programming, the two 1kΩ series resistors must be shorted out. These resistors normally protect the IC inputs from accidentally applied voltages above 3.3V during operation (eg, you can use a 0-5V trigger signal if necessary).

Normally, to trigger a sound, either TRIG1 or TRIG2 is pulled to ground although the unit can be re-configured to invert the trigger logic.

Software

IC1's software must perform a number of tasks. As explained earlier, it goes into and out of sleep mode as necessary, powering up the USB interface and the serial flash chips only when needed. Pin-change interrupts on pins 17, 27 & 28 are used as wake-up signals.

When the USB interface is enabled, the module appears as a virtual serial port. The XMODEM protocol is used to upload audio files (8-bit or 16-bit mono WAVs). Configuration commands are sent as text over the serial port and the module responds to indicate that they have taken effect. You can also query some information from the module, such as how much memory is free.

When you upload a WAV sound file, it checks that the format is valid and that there is enough free memory, then stores it. If a 16-bit file is uploaded, it is converted to 12-bit format on-the-fly, to save memory and speed up the playback code.

There are a number of configuration options such as whether the sounds are looped, whether the sound continues playing to the end of the file once the trigger input is released, which input has priority, how to deal with multiple sounds and so on. These are set using text commands over the USB serial interface and stored in IC1's flash memory to be used when the unit is triggered (more on this later).

Features & Specifications

Module size: 59 x 28 x 13mm

Trigger inputs: 2

Number of sound effects: 1-8, triggered round-robin or random

Audio sampling rate: 8-48kHz

Audio resolution: 8-bit or 12-bit

Sound memory: 108KB, 620KB or 1.12MB

Total playback time: 1.5-125 seconds depending on sampling rate & data memory (see Table 1)

Output power: Approx. 100mW into 8Ω

Supply options: CR2032 lithium cell, USB 5V, DC 5-24V, AC 5-24V peak-to-peak

Cell operating voltage: 2.15-3.3V (2.3-3.3V with memory >108KB)

Standby current: typically 9-14µA, depending on installed memory

Standby cell life: >1 year

Playback cell life: 4-24 hours, depending on sound volume, etc

Configuration interface: USB (mini type B socket)

USB protocol: virtual serial port (CDC), file transfer via XMODEM

Computer operating system: Windows XP, Vista, Windows 7*

** In theory, the module will work with Linux and Mac OSX using the CDC driver but we haven't tested it. The driver will need to recognise our Vendor ID and Product ID (04D8, FD52).*

Construction

The Digital Sound Effects Module is built on a double-sided PCB coded 09109121 and measuring 28 x 59mm. Fig.4 shows the parts layout. The first job is to fit the surface-mount devices to the top side of the PCB.

Start by laying the board flat on your workbench and fitting the USB connector (CON2). This has two plastic locating posts on the underside which go into matching holes on the PCB. Ensure that the socket end is at the edge of the PCB and that the connector is sitting flat, then solder one of the mounting feet.

That done, check that the five pins are properly aligned on their pads, then solder the other three feet plus the five pins. You will have to angle the soldering iron when soldering the pins, as they are under the main body of the connector.

Don't worry about solder bridges at this stage; just make sure they are soldered correctly. It's then simply a matter of using solder wick to clean up the bridges (note: adding a bit of flux paste makes this much easier). Finally, check that the bridges are gone using a magnifier; if not, add more flux and fix them.

The four SOT-23 (small-outline transistor package) devices can be installed next (ie, D1, D2, Q1 & ZD1). Be sure to remove them from their packaging one at a time so you can't get them mixed up (they look virtually identical).

In each case, it's just a matter of placing a small amount of solder on one of the pads, then reheating the solder while you slide the device into place. If it isn't aligned properly, simply reheat the solder and nudge it until it is correctly aligned. The other pins can then the soldered.

Follow with the ICs, taking care to get the orientation correct. In each case, pin 1 is indicated with a dot on the PCB. IC1 and IC2 should have a divot near pin 1 while the other two ICs (if fitted) have a bevelled edge on the same side as pin 1.

As before, it's just a matter of applying some solder to one of the end pads, then reheating this solder as the device

Serial Commands For The Sound Effects Module

Commands are sent to the Digital Sound Effects Module by typing them into the serial terminal. There are three basic types of command: those which give you information, those which are used to upload sound files and those which are used to change the module's configuration.

Most commands have an immediate effect and respond with information after you press the enter key. If there is an error (eg, you mistyped the name of the command), it will respond with information about what has gone wrong.

Having prepared the sound files, the next step is to use the Send command to upload them. If you have a speaker wired up at this stage, you can then check that everything is working using the Play command.

Here is the list of available commands with some information about how to use them.

Command: "Info"
Description: displays the firmware version, amount of memory installed and free, what sound files are loaded and the configuration settings.
Example:
Info
SILICON CHIP Sound Effects Module v1.0
Total memory: 1131.9KB
Free memory: 721KB
Sound #1: 22050Hz, 12-bit, 12.8s, 411KB, loop, stop immediately
Trigger #1: NO, sound #1, priority, random
Trigger #2: NO, no sounds, round robin
Unsaved configuration changes

Command: "Clear all"
Description: deletes all sounds loaded into the Module, freeing up all memory for new sounds
Example:
Clear all
Memory cleared, 1131.9KB free

Command: "Clear last"
Description: deletes the last sound loaded into the Module, freeing up the memory it occupied.
Example:
Clear last
Sound #2 cleared, 721KB free

Command: "Send"
Description: initiates the upload of a sound file to the module. After a successful Send command, the sound is uploaded via XMODEM. The sound file is given the next available index, starting with #1.
Example:
Send
Ready for file via XMODEM
Saved to index #1

Command: "Abort"
Description: cancels a pending Send command. Can be used if the transfer failed for some reason but the unit is still waiting for it to finish. You can also re-start a transfer by doing a Send command again.
Example:
Send
Ready for file via XMODEM
Abort
Transfer aborted

Command: "Play <index>"
Description: immediately plays back the sound loaded in the specified location. The USB interface does not respond during playback. A response will be sent once playback is complete and the serial port interface is then ready for more commands.
Example:
Play 1
Playing file #1 (12.8s)...
Playback complete

Command: "Options <sound index> <options>, <option> ..."
Description: once you have uploaded a sound file, you can set some options which determine how it is played back. By default, when triggered, the sound will play once and won't stop until the end of the file (unless interrupted, see below). If you want it to loop as long as the trigger input is held on, use the "loop" option (or "once" if you don't; this is the default). If you want the sound to stop as soon as the trigger input is released, rather than wait for playback to complete, use the "partial" option (the default is "complete").
Example:
Options 1 loop, partial
Sound #1: 22050Hz, 12-bit, 12.8s, 415KB, loop, partial

Command: "Sounds <trigger index> <sound index>, <sound index> ..."
Description: allocates one or more sounds to a trigger index (1 or 2). Sounds can be allocated to either or both trigger inputs. This determines which sounds are played back when the specified trigger input is activated (one at a time, see below for information on how they are chosen).
Example:
Sounds 1 1
Trigger #1: NO, sound #1, priority, random

Command: "Trigger <trigger index> <option>, <option> ..."
Description: sets the options for trigger 1 or 2. The available options are "NO" or "NC" to set the input mode to suit normally open or normally closed switches (or active low and active high signals, respectively), "priority" (which allows it to interrupt sounds which are triggered by the other input) or "nopriority", "roundrobin" (with multiple sounds allocated, they are played in sequence) or "random" (with multiple sounds, one is randomly selected each time).
Example:
Trigger 1 priority, random
Trigger #1: NO, sound #1, priority, random

Command: "Save"
Description: configuration commands (except for Send) are not permanently saved until this command is executed. If you don't save configuration changes, they will be lost when the unit loses power.
Example:
Save
Configuration saved

Digital Sound Effects Module: Parts List

1 PCB, code 09109121, 28 x 59mm
1 PCB-mount button cell holder (Jaycar PH9238)
1 CR2032 lithium cell
1 5-pin header, 2.54mm pitch (CON1)
1 SMD USB connector, mini-B type (CON2) (eg, Altronics P1308)
1 8Ω mini-speaker (eg, 27mm or 40mm diameter)
1 100mm length 2-wire ribbon cable
1 USB cable, type-A plug to mini-B plug
4 M3 x 9mm tapped Nylon spacers
4 M3 x 6mm machine screws

Semiconductors

1 PIC18F27J53-I/SO microcontroller programmed with 0910912A.hex (IC1)
1 LM4819 audio amplifier [SOIC-8] (IC2) (Digi-Key LM4819MXCT-ND) OR
1 LM4889MA 1W audio amplifier [SOIC-8] (IC2) (Element14 1286916)
1 LM2936MP-3.3 50mA 3.3V LDO regulator [SOT-223] (REG1) (Element14 1469062)
1 DMP2215L P-channel Mosfet [SOT-23] (Q1) (Element14 1713864)
1 5.1V zener diode [SOT-23] (ZD1) (Element14 1431236)
2 BAT54C dual Schottky diodes [SOT-23] (D1, D2) (Element14 1467518)

Capacitors (SMD 3216/1206 unless specified)

1 100µF PCB-mount low-profile electrolytic (eg, Element14 9452567)
1 47µF 25V PCB-mount low-profile electrolytic (eg, Element14 1165523)
1 10µF
4 1µF
1 10nF
2 470pF

Resistors (SMD 3216/1206, 0.25W 1%)

2 620kΩ
2 1kΩ
4 10kΩ
1 10Ω

Optional parts for longer playback time

2 AT25DF041A-SSHF-B 4Mbit flash memory ICs [SOIC-8] (IC3, IC4) (Element14 1636622)
2 100nF ceramic chip capacitors [3216/1206]

Note: the PCB & the programmed PIC micro are available from SILICON CHIP PartShop.

is slid into place. That done, solder the diagonally opposite pin, then solder the remaining pins, ignoring the inevitable solder bridges.

Removing the solder bridges

Once the device is in place, apply a thin layer of flux paste along both rows of pins, then clean up the solder bridges with solder wick. That's done by first placing the solder wick alongside (but not on top of) the pads. The soldering iron is then placed on top of the solder wick and the wick gently slid towards the solder on the pads.

As the wick heats, it will start to melt the flux and the excess solder, creating visible smoke. At that point, you can slide it right up against the pins and most of the excess solder should then be sucked into the braid.

Repeat this procedure until all the solder bridges are gone. It's not strictly necessary to clean off the flux residue provided you are using no-clean (non-corrosive) flux. However, if you do want to clean it off, this can be done using pure alcohol (eg, isopropanol).

For a more detailed description on soldering in SMD ICs, refer to pages 80-82 of the June 2012 issue.

The passive SMDs are next on the list. These include nine 3.2 x 1.6mm (3216) resistors and 8-10 similarly sized ceramic capacitors. The resistors have their value code printed on top but the capacitors will be unlabelled. As before, the best tactic is to remove them one at a time from their packaging, so you don't get them mixed up.

Regulator REG1 is the last SMD components to be installed. It's mounted

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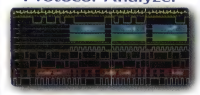
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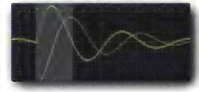
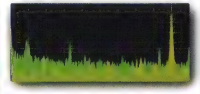

Spectrum Analyzer

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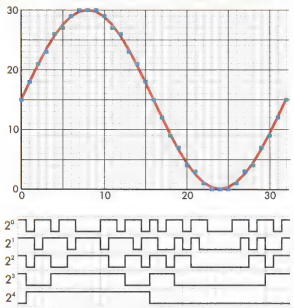


Fig.5(a): 32-sample sinewave with 30 voltage steps (5-bit resolution)

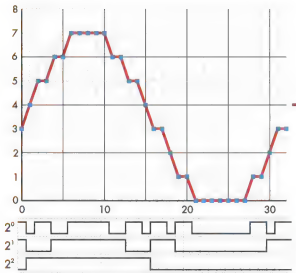


Fig.5(b): three most significant bits with corresponding waveform

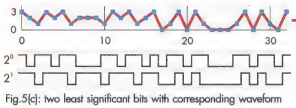


Fig.5(c): two least significant bits with corresponding waveform

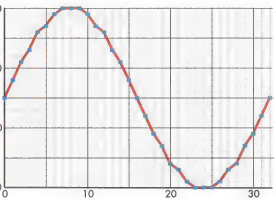


Fig.5(d): summing waveforms with appropriate scaling reproduces original wave shape; deviations are due to limitations of the 5-bit resolution

Using PWM To Reproduce PCM Audio

Uncompressed digital audio is stored in Pulse-Code Modulation or PCM format. This consists of a series of numbers which represent a proportional voltage at a point in time. The voltage is sampled at a fixed rate (the sampling rate) and stored. The resulting numbers form a representation of the audio waveform.

Refer to Fig.5(a); this shows a sinewave converted to 5-bit PCM with 32 samples. With five bits, we have about 30 voltage steps and as you can see, some of the sample points (blue) don't quite line up with the original waveform (red). In reality, we use more than five bits but this is just an example.

At the bottom of Fig.5(a) is a plot of the five data bits. Consider the first sample (left-most blue dot), which has a value of 15. This is encoded as $2^0 + 2^1 + 2^2 + 2^3$ (1 + 2 + 4 + 8) and hence the bits corresponding to these numbers are high (one) whereas the top bit, 2^4, is initially low (zero). Some bits then flip as the sampled value changes and a new sample is binary encoded.

Now look at Fig.5(b). We've taken the three most significant bits (MSBs) and re-numbered them to start from zero, without changing the data. The resulting sample values are plotted above. The resulting waveform has the same general shape as the original but it lacks the fine details since the least significant bits (LSBs) are gone.

This is a type of audio decimation; dropping some of the LSBs is an easy way to reduce the amount of data required to store a PCM stream but it also reduces the audio quality. It's how we convert 16-bit audio to 12-bit for storage in the Digital Sound Effects Module (as mentioned early in the main article).

In Fig.5(c) we plot the two LSBs missing from Fig.5(b). This

in a similar manner to the ICs and SOT-23 devices.

Through-hole parts

Now flip the PCB over and mount the cell holder. The two electrolytic capacitors can then be fitted, with their longer leads going through the holes marked "+" on the PCB.

Finally, complete the assembly by fitting four M3 x 9mm tapped Nylon spacers to the corner mounting holes. These are secured using M3 x 6mm machine screws.

Programming

If you don't have a pre-programmed PIC (available from the SILICON CHIP PartShop), program it now. To do this, temporarily short out the two 1kΩ resistors (eg, using a lead off-cut) and then plug (or solder in) a 5-way pin header in for CON1 (friction will hold it in place).

That done, connect an ICSP (in-circuit serial programmer) with its pin 1 orientated as shown. If you are using a

shows the "residual" or the difference between the original and decimated waveforms. If we add this waveform to the decimated version with the correct ratio, we reconstruct the original 5-bit audio data, as shown above. This summing can occur either digitally or in analog.

The 12-bit audio used in the Digital Sound Effects Module sounds almost as good as 16-bit audio but only requires 75% as much memory. Using the technique shown here, we split each 12-bit sample into the six MSBs and the six LSBs.

These sample values are each then converted to an analog voltage using a pair of 6-bit PWM (pulse width modulation) outputs on the microcontroller. A sample value of 0 give us a 0% duty cycle and a value of 63 (2^6 - 1) gives us a near-100% duty cycle. The PWM square waves pass through low-pass RC filters which remove most of the switching noise and give us smoothly varying voltages which are proportional to the duty cycles and hence sample values.

All that's left is to then sum the two resulting analog waveforms in the correct ratio (64:1). This is achieved using a resistive voltage divider/mixer and we then have an analog signal which closely approximates the original audio waveform, to within about 0.025% (1/4095).

Oversampling

Using 6-bit PWMs gives a maximum switching frequency of 188kHz (the 12MHz CPU clock divided by 2^6 or 64). We want a switching frequency well above 20kHz so that we can filter out most of the switching harmonics without affecting the audible frequencies (20Hz-20kHz).

A typical audio sampling rate is between 8kHz and 48kHz, giving between 23.4 and 3.9 PWM pulses per audio sample. To give a smooth output waveform without lowering the switching frequency (for the reasons explained above), we generate intermediate steps for the samples so that we can update the PWM duty cycle after each pulse.

You can think of this as a joining-the-dots exercise (see Fig.5(b)). The original samples are shown as blue dots but we could also put dots anywhere along the red line segments joining them to get an estimated intermediate sample value that we can then use to update the PWM duty cycles, making the output less "steppy" and more smooth. This is shown in the scope grabs in the main article.

PICkit programmer, you can power IC1 at 3.3V from its inbuilt power supply.

Alternatively, you can connect a USB cable from a PC for power (although the device won't be detected yet). The software, 0910912A.hex, is available from the September 2012 downloads section on the SILICON CHIP website (**www.siliconchip.com.au**).

Unplug the CON1 pin header when you have finished programming IC1.

Installing the driver

Assuming that the PIC micro has been programmed, the next step is to plug the unit into a USB port and check that it is detected. A message should pop up adjacent to the System Tray saying "Installing device driver software" (Windows 7) or "Found New Hardware" (XP) – see Fig.6. You will then be prompted to locate a driver. You need to use the SILICON CHIP USB serial port driver, which is also available for free download from the SILICON CHIP website.

This is the same driver as used for the Maximite and several other SILICON CHIP projects. The accompanying panel details the driver installation and tells you how to determine which COM port number has been assigned.

That done, download and install the free serial terminal program TeraTerm Pro (available from **www.ayera.com/teraterm/**). Launch it and open the port assigned to the USB driver.

Now type "Info" and press enter and you should get a response confirming that the module is working and showing its firmware version and the amount of free memory.

Preparing the sound files

You now need to prepare the sound file(s) so that they can be uploaded to the module. They must be saved as mono 8-bit or 16-bit PCM WAV files with a sampling rate of between 8kHz and 48kHz.

To check the format of your files or to convert them if necessary, you can use a free sound-file editing program called "Audacity" (**http://audacity.sourceforge.net/download/**).

Load up Audacity and open a sound file. At the left side of the window, you can see whether it is stereo or mono. If stereo, use the "Stereo Track to Mono" option from the "Tracks" menu to mix them together.

At the bottom of the screen, select the desired sampling rate (labelled "Project Rate (Hz)"). Keep in mind that higher sampling rates give better audio quality but also use more memory. There's no point selecting a higher rate than that of the original file (which will be the default).

Volume adjustment

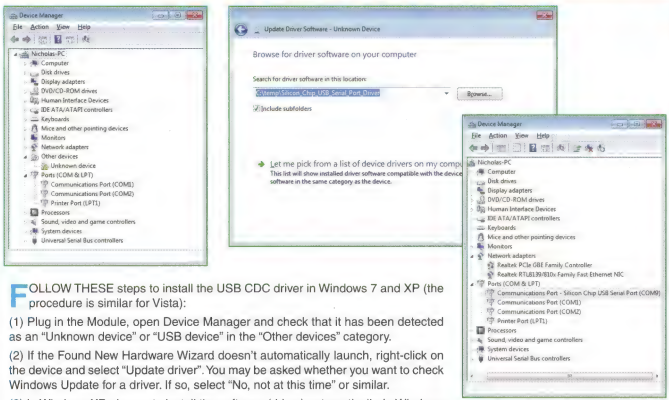
The volume adjustment can now be done. The module plays the file back with a fixed scale (the supply voltage will affect the volume somewhat).

If your sound files are full-scale (ie, normalised), then the peaks may be slightly clipped due to the limited output power of the unit, especially if they have heavy bass. For best results, the audio file should be normalised to about 1dB below full-scale. This can be achieved by using the "Amplify" option from the "Effects" menu, then reducing the dB level shown by 1dB and clicking "OK".

If you find the sound is too soft or too loud, you can repeat these steps later but turn the dB level up or down as necessary. Keep in mind that as you increase the amplification, you may find the sound gets distorted due to clipping. In some cases though, this

Fig.6: these are the messages that appear adjacent to the System Tray in Windows 7 (top) and Windows XP (bottom) when the Digital Sound Effects Module is initially plugged into a USB port (ie, before the USB driver is installed).

How To Install The USB Driver



FOLLOW THESE steps to install the USB CDC driver in Windows 7 and XP (the procedure is similar for Vista):

(1) Plug in the Module, open Device Manager and check that it has been detected as an "Unknown device" or "USB device" in the "Other devices" category.

(2) If the Found New Hardware Wizard doesn't automatically launch, right-click on the device and select "Update driver". You may be asked whether you want to check Windows Update for a driver. If so, select "No, not at this time" or similar.

(3) In Windows XP, choose to install the software (driver) automatically. In Windows 7, select the "Browse my computer for driver software" option. For Windows XP, select "Install from a list or specified location". Then for both operating systems, browse for and select the folder containing the SILICON CHIP USB driver.

(5) You will now likely get a warning that the driver is not signed. Choose to continue and install the driver anyway.

(6) Verify that the driver installation is successful. The device should now show up under the "Ports" category in Device Manager. Make a note of the COM port number assigned.

may be acceptable – it depends on the characteristics of your sound.

Saving the file(s)

Now use the Export function from the File menu. If you want to upload the file to the module with a 12-bit resolution, select "WAV (Microsoft) signed 16-bit PCM" from the drop-down at the bottom of the file dialog (it will be converted from 16-bit to 12-bit by the module).

For an 8-bit resolution, select "Other uncompressed files", then click the Options button. For Header, choose "WAV (Microsoft)" and for Encoding, select "Unsigned 8 bit PCM". Then click OK.

You can now select a location, type in a name and press the Save button. The file is then ready to be uploaded. Repeat this process if you are going to upload multiple sound files.

With the files prepared, plug the module into a spare USB port, load up TeraTerm Pro (or if you prefer, another XMODEM-capable terminal program) and connect to the virtual serial port, as described earlier. You can now upload the files using the "Send" command, as described in the "Serial Commands For The Sound Effects Module" panel.

Using the module

With the sounds uploaded and the configuration set (don't forget to save it!), you are ready to hook up the power, speaker and trigger inputs.

Connect the speaker across the two solder pads. Any 8Ω speaker will do and the more efficient it is, the better. It will also sound much better if it is baffled.

The simplest way to do this is to mount the speaker in a timber box. A tuned box will give the best sound quality but in general, any baffle is better than none.

You can connect the speaker to the terminals either way around, since the phase doesn't matter.

There is also space to glue or tape a small (~27mm) speaker to the back of the PCB, next to the cell holder. You can do this if you're really pressed for space and your sound requirements are modest. However, it will limit the volume and give poor bass response.

The trigger switches must be connected between the trigger input pads and the nearby ground pad, either via a pin header connector or by soldering thin wires (eg, ribbon cable) directly to the PCB. You can use microswitches, pushbuttons, reed switches or even the output of a microcontroller or digital logic IC to trigger the unit.

Having done all that, it's just a matter of inserting the lithium cell into its holder or wiring up the external power supply (AC or DC) to CON3. You can then activate one of the trigger inputs and check that the sound(s) play back as they should. SC

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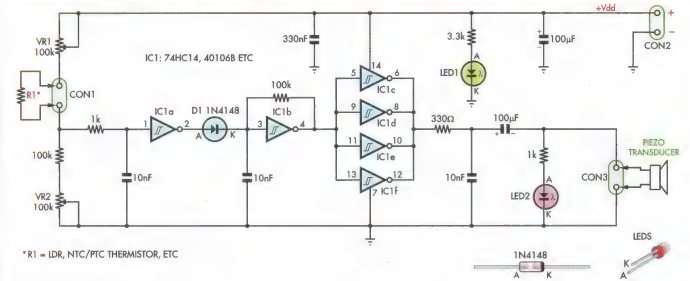
CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



Simple sound & light alarm

This simple alarm circuit is triggered when the resistance of the sensor R1 goes below a certain limit. The sensor can be any type which changes its resistance such as an LDR, switch contact, pressure mat etc.

Trimpots VR1 and VR2 set the threshold level and depending on the resistance range of the sensor, it may be possible to omit VR1.

The circuit itself is an oscillator based on one CMOS Schmitt trigger inverter, IC1b. This is enabled or disabled, depending on the resistance of the sensor.

If the sensor resistance is high, pin 1 of IC1a will be low and its output at pin 2 will be high. This will pull pin 3 of IC1b high via diode D1 and this disables the oscillator.

The remaining inverters in the 74C14 are paralleled to drive a piezo transducer and LED2.

The frequency of the alarm is set by the 100kΩ feedback resistor and 10nF capacitor associated with oscillator IC1b.

Petre Petrov, Sofia, Bulgaria. ($35)

Low-voltage LED lighting system has remote-controlled dimming

This circuit was designed to replace a conventional mains-voltage lighting system with low-voltage LED lighting powered by solar panels. It provides remote-controlled switching and dimming functions, eliminating the need for switches and dimmer control wiring.

The circuit is based on switching regulator IC1 which drives Mosfet transistor Q1 in a voltage boost configuration. Each time Mosfet Q1 is turned on, current flows in inductor L1 and energy is stored in its magnetic field. When Q1 turns off, the magnetic field collapses and the stored energy is dumped via Schottky diode D1 into a 100µF 35V capacitor and two series strings of high-intensity white LEDs. The positive supply for the LEDs is maintained at a relatively constant value by negative feedback to pin 2 of IC1.

Eliminating LED flicker

Switching regulators operating at low duty cycles can have subharmonic oscillations, where the output voltage "hunts". If the oscillation frequency is low enough, this will result in flickering LEDs. This circuit overcomes that problem by controlling the current through each string of LEDs using regulated current sinks comprising Darlington transistors Q2 & Q3 and op amps IC3a & IC3b. This also ensures equal current sharing between the two strings of LEDs.

These op amps are driven by a PWM (pulse width modulated) signal produced at the GP2 output (pin 5) of PIC microcontroller IC2, in response to signals received by infrared receiver IRR1. The PWM signal is converted to a DC voltage by the RC low-pass filter at pin 5 of IC2.

Learning function

The microcontroller is programmed with a learning function so that it can be used with any IR remote control of the kind typically used with domestic appliances such as

TVs, VCRs and DVD players. Before the microcontroller will respond to the remote control it must "learn" the codes for three different functions, which are called here UP, DOWN and ON/OFF, respectively.

On initial power-up, the microcontroller automatically enters a learning mode, which is indicated by LED21 lighting up. Point the remote control at the IR receiver and press each button in turn in the order given above. As the code for each button on the remote control is learned, LED21 will momentarily turn off and then back on again.

After the last button has been pressed, LED21 will turn off and stay off, indicating that the codes have been successfully learned. The codes can be changed at any time by pressing PB1 and then repeating the steps as described above.

If at any stage the LED does not respond to a button press, try pressing the same button again or try pressing a different button instead. If that doesn't work it may be that the protocol used by the remote control is incompatible with that used by the microcontroller.

The prototype was tested with a number of remote controls of different brands and was found to work with all but one, which in the latter case was intended for a games machine and which used a protocol that doesn't appear to be typical of TV remote controls and the like.

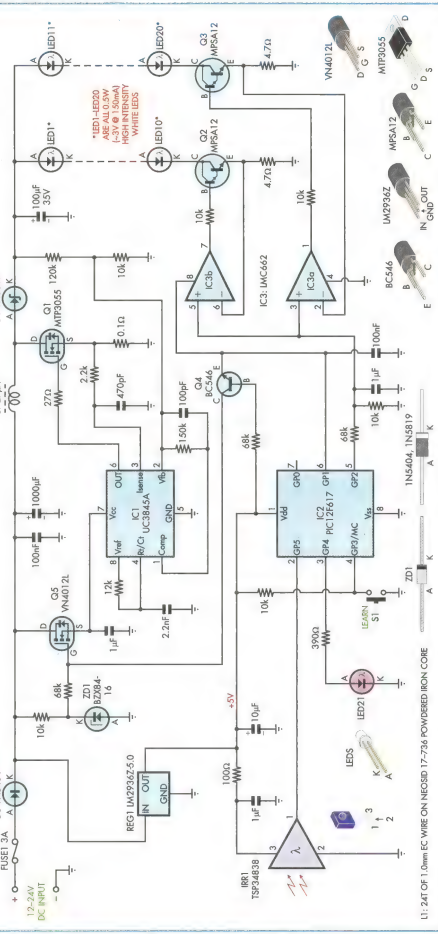
Remote functions

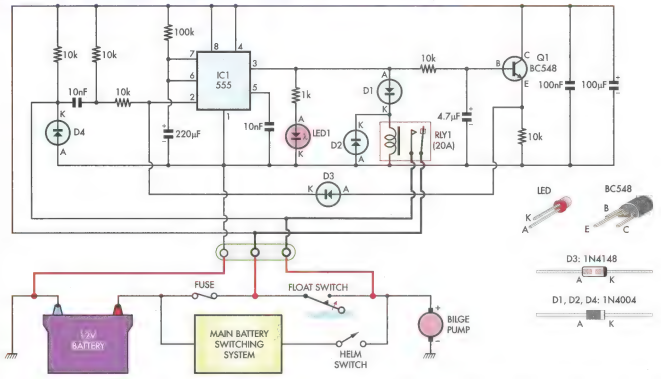
The remote functions are as follows: pressing the UP button increases the LED brightness, while pressing the DOWN button reduces the LED brightness. There are 16 levels of brightness, increasing in steps of approximately equal ratios of LED current.

As the name implies, pressing the ON/OFF button alternately turns the LEDs on and off. With the LEDs turned off, the driver is in standby mode, meaning that the circuit draws a small current, mainly due to need for the IR receiver to be turned on for the remote control to function. The current drawn by the prototype was less than 5mA at 12V in standby mode.

The software, remotelight.zip, is available on the SILICON CHIP website.

Herman Nacinovich,
Gulgong, NSW. ($70)





Bilge pump time extender

All large boats have bilge pumps which are activated by a float switch once the water in the hull reaches a set level. The pump then runs until the water falls to below the switch trip point.

The power supply for this automatic activation is direct to the battery via a fuse as it must operate even when the boat is not attended and the main battery switch has been turned off. Such pumps can also be manually activated via a switch, usually located on the helm and connected to the boat's DC distribution system via the MBSS (Main Battery Switching System). So this switch works only when the MBSS is switched on to power the boat.

My bilge pump would switch on automatically with about 55mm of water in the hull and would switch off automatically, leaving about 45mm of water in the hull. This remaining amount of water was causing considerable condensation and resultant unsightly surface rust on the engines. However after the automatic switch had re-opened, by then using the manual switch for a further 30 seconds, the amount of water remaining in the hull would drop to less than 10mm (the limit of the pump), thus significantly reducing the amount of water remaining.

Automatic operation of the bilge pumps is critical to a boat's survival when water enters the hull. So when considering extending the automatic timing period it was imperative to do so in a way that would not compromise the reliability of the existing components. The circuit shown connects to the original bilge pump/float switch circuit such that if the added circuit fails, the bilge pump should still operate as it did originally.

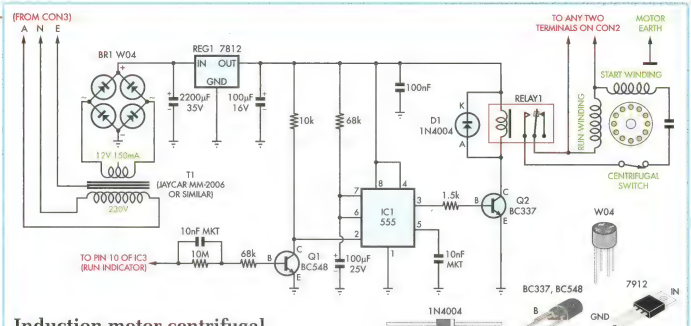
This circuit can be used to extend the automatic timing period in bilge pump systems that use a separate float switch and pump. Some boats use integrated float switch/pumps and are not suitable as the float switch output is not available externally. It should also be noted that bilge pumps should not be run dry, hence the extended timing period must be only long enough to maximise the removal of the water.

The circuit is based on a 555 timer operating in monostable mode. The trigger circuit (pin 2) needs to be able to detect a trigger signal and commence timing when the float switch opens but ignore a trigger signal when the relay in the circuit opens, otherwise the circuit would continually trigger. To achieve this, transistor Q1 is switched on when the relay is energised and stays on for a short period once the relay is de-energised. By connecting Q1 back to pin 2, it effectively allows the timer to ignore the trigger signal from the relay opening.

When the float switch opens, pin 2 of 555 timer IC1 receives a negative-going trigger pulse and its output at pin 3 goes high for about 30 seconds, as determined by the 100kΩ resistor and 220µF capacitor connected to pins 6 & 7. This lights LED1 and energises relay RLY1 to switch on the pump.

Once the timing period is complete, pin 3 of IC1 goes low and the relay, bilge pump and LED1 switch off immediately while Q1 remains on for just over a second. This ensures that the 555 ignores the trigger pulse that it receives when the relay contacts open.

If mounted in the bilge, ensure that the circuit is housed in an IP65-rated enclosure and that a water-tight cable gland is used for the wiring. The wiring used must be capable of taking the full current of the bilge pump, so check your



Induction motor centrifugal switch over-ride

The AC Induction Motor Speed Control featured in the April & May 2012 issues of Silicon Chip cannot be used with motors that have a centrifugal switch. That's because the centrifugal switch may re-connect the motor's start winding if the speed drops to a low enough value. Nor can a motor be started and run at a low voltage because the centrifugal switch would never disconnect the start winding. The result would be a burnt-out start winding.

This circuit will allow these motors to be used with the Induction Motor Speed Control, provided that the motor is started at normal voltage, ie, at about 230VAC. It's essentially a time-out circuit which allows the start winding to be initially connected and then switched out after a period of about 10 seconds. To install it, you must be able to gain access inside the motor, to the centrifugal switch terminals. All wiring to the motor and centrifugal switch must be 250VAC-rated and double-insulated.

In essence, the circuit is a 555 timer controlling a relay that has its contacts in series with motor's start winding and centrifugal switch. The timer is under the control of the Induction Motor Speed Control. When the controller applies power to the motor, pin 10 of its microcontroller (IC3) goes high to turn on the RUN LED. This signal is used to momentarily turn on transistor Q1 which shorts pin 2 of IC1 to 0V and allows the timing sequence to start. This enables the relay and the motor's start winding will be energised.

After 10 seconds, pin 3 of IC1 goes low, turning off transistor Q2 which de-energises the relay and disconnects the motor's start winding.

The timer cannot be restarted until the whole circuit is powered off and then on again. Note that the speed controller will need to be powered up and the motor started via a switch from the GND terminal on CON6 to the RUN terminal on CON5.

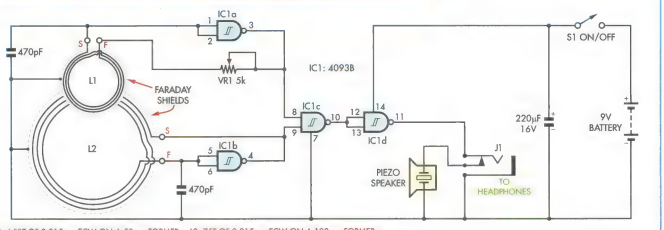
Geoff Coppa,
Toormina, NSW. ($60)

pump's specifications. My pump is rated at 1600 GPH and draws 7A, so I used cable rated for 10A.

To connect the circuit to the boat's original wiring, identify the battery positive, battery negative and float switch wires. These wires will be found connecting to the float switch and bilge pump in the lowest part of the hull (or section of hull).

Attach these wires to the circuit as shown. My boat uses bullet connectors, so I made a pair of splitter cables with two bullet connectors at each end. These were connected in-line with the existing wiring and also to the time extender circuit. Be sure to waterproof the bullet connections.

Dean Brookes,
St Ives, NSW. ($50)



L1: 150T OF 0.315mm ECW ON A 50mm FORMER L2: 75T OF 0.315mm ECW ON A 100mm FORMER

Simple metal locator uses overlapping coils

This simple and yet sensitive double-coil metal detector employs a small search coil for shallow detection depth and a large search coil for locating deeper metal objects. Each coil has its own oscillator which is based on a Schmitt trigger NAND gate, part of a 4093 CMOS chip.

IC1a serves as the first search oscillator while IC1b is the second oscillator and the capacitors of the respective oscillators are connected so that they operate in opposite phase. The search oscillators are tuned to very nearly the same frequency and their outputs are fed into IC1c, which functions as a mixer that produces an audio tone equal in frequency to the difference between the two oscillator frequencies.

IC1d drives a piezo speaker or a set of 32-ohm headphones. While the current consumption of the circuit is just 5mA with a piezo speaker and 6mA with a set of headphones, the audio level is more than adequate.

The search coils are wound as follows. L1 consists of 150 turns of 0.315mm (30 SWG) enamelled copper wire wound on a 50mm diameter former (eg, a piece of plastic conduit). Remove the completed coil from the former and tape it firmly all around with insulating tape. Then fabricate a Faraday shield for the coil by wrapping narrow strips of aluminium foil around it. Make sure that the shield has a 10mm gap at one point. A short length of wire should be connected to the shield which should be covered with insulating tape.

Construct L2 in the same way but with 75 turns of 0.315mm (30 SWG) enamelled copper wire around a 100mm former. Use a non-metallic baseplate of suitable size and place the large coil first, then place the small coil on top of it with about 25mm overlap. Connect the two coils so that they are opposite in phase. The screens of the cables and the Faraday shield wires of the coils should be connected to ground.

Tuning up and checking out the detector is easy. Position the search head away from any metal object. Simply switch the detector on and set VR1 to about mid-way. Now move the small coil slightly back and forth until you hear an audio tone in the speaker or the headphones with a null in the middle. Fix the coils firmly in place and choose one side and slowly tune VR1 to lower the frequency as much as possible for maximum sensitivity. At this point, one coil is sensitive to ferrous and the other to non-ferrous metal objects.

Pass a metal object over the coils. The tone should be shifted in frequency, upward in one coil and downward in the other. Having done the adjustment, secure the coils tightly to the baseplate.

Mahmood Alimohammadi, Tehran, Iran. ($45)

Compensated probe measures peak mains AC voltage

The article on mains waveform distortion in the April 2012 issue highlights the severe clipping due to capacitive input power supplies; both conventional and switchmode types. This clipping can lead to errors in voltmeter readings, depending on the measurement technique employed. Typical moving coil meters use a diode bridge and respond to the average value but are calibrated to read RMS, assuming it is a pure sinewave (with a "form factor" of 1.1).

This circuit was developed to give a simple method of reading the peak voltage of an AC waveform and it compensates for the forward voltage of the detector diodes. Looking at Fig.1, diodes D1 & 4 detect the positive and negative peaks while D2 & D3 compensate for their forward voltage drop; D2 for D4 and D3 for D1. The compensation is provided by double-pole switch S1 which allows an external digital multimeter to read the positive or negative peak value of the waveform.

It works like this: for positive half-cycles of the waveform, current passes through diodes D1, D2 and resistor R1. As a result, capacitor C1 is charged to the positive peak voltage minus the voltage drop across D1. For negative half-cycles, current passes through D3, D4 & R2

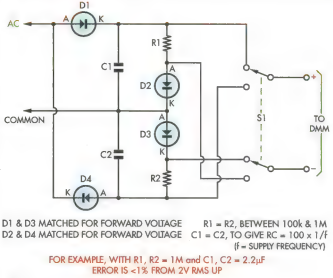


FIG.1

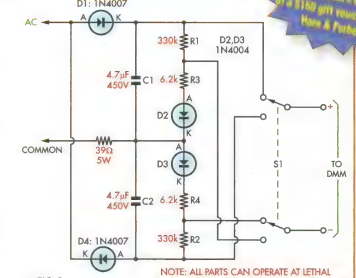


FIG.2

NOTE: ALL PARTS CAN OPERATE AT LETHAL VOLTAGE WHEN MEASURING THE AC MAINS

and capacitor C2 is charged to the negative peak voltage minus the voltage drop across D4.

To measure the positive peaks, switch S1 connects the DMM to measure the voltage across R1, D2 & D3. This means that it is measuring the voltage across C1 plus the voltage across D3. Hence, D3 adds in the voltage lost across D1. Similarly, to measure the negative peaks, switch S1 switches the DMM to measure across D2, D3 and R2. Hence, it is measuring the voltage across D2 and C2; D2 adds in the voltage lost across D4.

Fig.2 shows the final circuit with all values. Resistors R1 & R2 ensure that the current through D2 & D3 is larger than the DMM load current. The resistor tolerance is not critical but the voltage rating must be high enough (some 250mW resistors are only rated at 250V maximum). Also the wattage must be adequate, eg, a 1MΩ resistor with 500V across it will dissipate 250mW but a 100kΩ resistor at 500V would need to be rated at 2.5W.

The capacitor value should be such that the time constant RC ≈ 100 x 1/F, where F is the frequency of the supply. This gives a ripple on the detected DC of around 1% and a reading on the DMM of about 99.5% of the actual peak value. A larger RC value will reduce this error but means that the reading will be slower to track changes in the AC peak.

A 39Ω 5W resistor is included in the circuit to limit the input peak current at switch-on.

The circuit layout is not critical unless it is to be used for measuring high frequencies. For testing 230VAC mains voltages, it must be fully enclosed inside a small plastic box with four safety-style (ie, shrouded) 4mm banana sockets (two input, two output). Switch S1 must be rated to switch mains voltages.

Rodger Bean,
Watson, ACT.

Rodger Bean is this month's winner of a $150 gift voucher from Hare & Forbes

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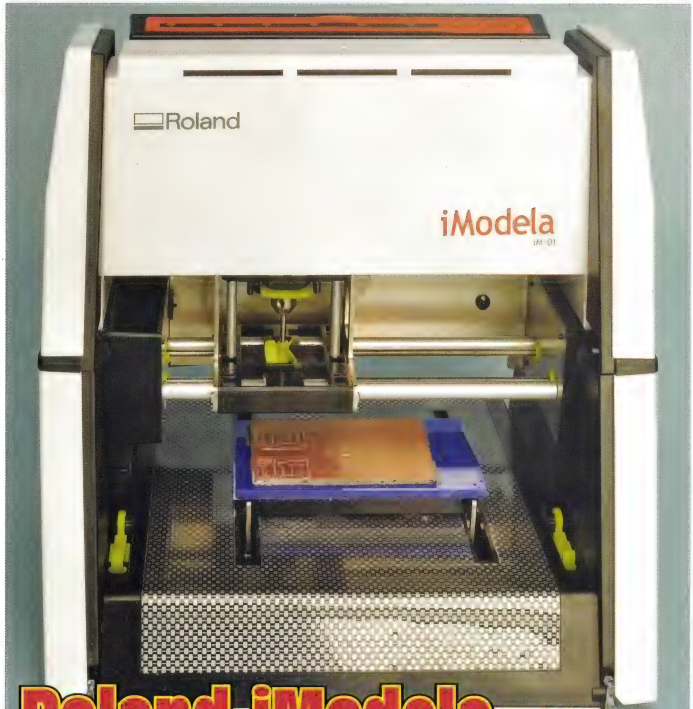


Roland iModela 3-axis CNC Router/Mill

Review by NICHOLAS VINEN

Looking for a small computer-controlled router/mill? This one won't break the bank but has quite a wide range of uses, from cutting 3D objects out of soft materials through to engraving metal and making PCBs – not just the tracks but the holes as well.

CNC stands for Computer Numerical Control and is a category that includes 3D printers, routers, mills, laser cutters and other similar devices.

The Roland iModela is a new product in their Modela range. It's smaller and more affordable than commercial CNC mills so will appeal to hobbyists, especially model makers. We think it also has uses in the world of electronics, such as making PCBs.

The first thing we noticed upon receiving the demo unit is how small it is – just 214 x 200 x 205mm.

That's tiny compared to most other CNC mills and that means it's portable, occupies little bench space and is easy to work on. The whole thing folds apart in seconds, giving you access to the milling bed, tool spindle and spindle motor. It's just as quick to pack up for storage.

The small size means the bed (or workspace) is also quite small at 86 x 55 x 26mm – so the largest object you can mill is slightly less than this.

Having done some tests, we can tell you that with the right cutting tool and a bit of patience, you can use the iModela to make PCBs, even those with relatively fine tracks (down to about 10 thou or 0.25mm wide); although having wider tracks makes the process easier.

As well as cutting PCB tracks and drilling holes for component leads, you can also use the iModela to mill the edges of the PCB, in order to cut it to a particular shape. This involves cutting a lot more material though, so you would probably need to use multiple passes to get a good result, removing the material around the PCB edges in layers.

Of course you can also use the iModela for its intended purpose which is to cut 3D objects out of solid plastic, wood and so on. The blank piece, to be cut or engraved, is taped or otherwise attached to the flat bed on the base of the machine.

Overview

The iModela consists of three basic parts: the milling bed, which moves in the Y-axis (forward/back); the spindle, which moves in the X- and Z-axes (left/right and up/down) and houses the spindle motor and cutting tool holder; and the electronic module which controls all four motors and communicates with the host PC.

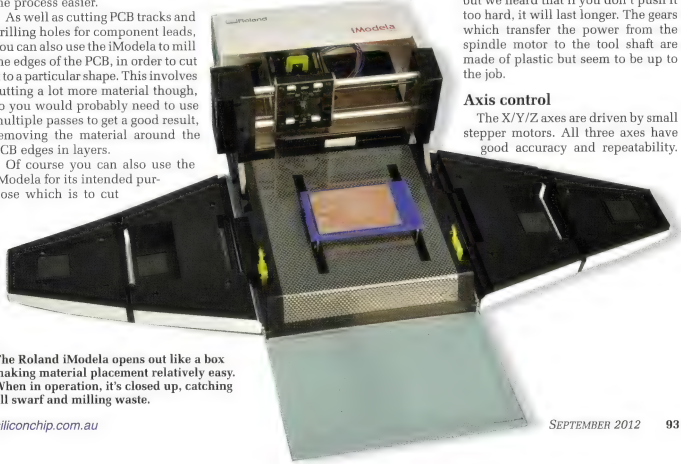
These are all housed in a plastic case, which also contains the swarf and dust generated while cutting.

The tool holder accepts 2.35mm (3/32") shaft tools only. While they are not the most common size bits, they are commonly used for hand-held engraving machines and for dentistry.

There is quite a range of milling bits available – we were able to find and purchase suitable milling and drill bits made from tungsten vanadium, tungsten carbide and high speed steel without too much trouble.

Accessories

The iModela comes in a sturdy plastic carrying case, along with some accessories.



The Roland iModela opens out like a box making material placement relatively easy. When in operation, it's closed up, catching all swarf and milling waste.

These include the power supply, USB cable, a spare spindle motor, fan attachment for tool shaft (to blow away swarf), Allen key for installing tools, double-sided tape, practice plastic pieces, starter cutting tool, lubricating grease, cleaning brush, software CD and user manuals.

The spindle

While they call the tool holder a "chuck", unfortunately it has no jaws. It's just a 2.35mm hole in a chamfered steel cylinder with a single grub screw to clamp the tool shaft.

It relies on the tool shaft being a tight fit in the hole so it doesn't wobble; while this works, it means you're limited to a fixed shaft size. It also means that if you are milling a relatively dense material and the tool shaft warps, it can be pretty hard to remove.

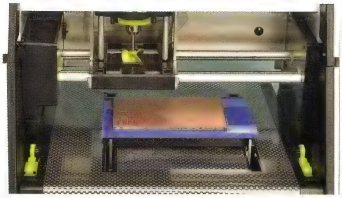
The spindle motor is a small Tamiya brushed DC job, which many readers will already be familiar with. It simply clips into the spindle housing, making replacing it a breeze.

This type of motor isn't terribly powerful but it's good enough for the type of materials you can cut with the iModela. It's certainly cheap and easy to replace when it wears out (or if you manage to burn it out).

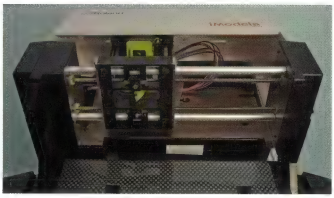
They say that you should get about 50 hours of operation from each motor but we heard that if you don't push it too hard, it will last longer. The gears which transfer the power from the spindle motor to the tool shaft are made of plastic but seem to be up to the job.

Axis control

The X/Y/Z axes are driven by small stepper motors. All three axes have good accuracy and repeatability.



The iModela's spindle is powered by a small hobby motor, which can be swapped in a matter of seconds. One spare is supplied with the machine.



Looking up into the business end of the machine, with the routing bit clearly visible. One of the big advantages of the iModela is that everything is relatively easy to get to.

The motors are strong enough that if the tool tip gets bogged down, the tool shaft will flex slightly rather than the axis motors becoming jammed.

This is one disadvantage of the 2.35mm shaft tools; they are more flexible than the 3.2mm types which can lead to inaccuracy if you're trying to cut away too much material at once.

Repeatability is important since if you are cutting an object in layers, you want to be sure that each layer lines up correctly.

Alignment is also important if you want to repeat an engraving pass but make it deeper. The iModela's precision is good and it seems to be able to return the cutting tool to the same point each time.

The iModela axes support steps as small as 0.001mm and the motors can microstep at 0.000186mm per increment! Microstepping helps smooth linear movements but doesn't necessarily help with absolute positioning. However 0.001mm is very good accuracy anyway, so there are no problems in this regard.

Control circuitry

The control circuitry is rather clever, especially the way that it adjusts the spindle motor speed. The spindle motor runs at about 10,000RPM with no load. As the tool digs in, this speed drops. The iModela automatically adjusts the motor current in response to its load, in order to avoid the tool jamming or the motor burning out.

This appears to work quite well. If the spindle jams or the motor encounters excessive load, the power to the motor is cut and you can rectify the problem before proceeding.

It's important to set the correct feed rate for the all three axes to suit the material you are cutting. If it's too slow, the job will take too long to complete while an overly fast feed rate can cause the motor speed to drop, resulting in poor cutting and in the worst case, a broken cutting tool.

For milling PCBs, if you use the right bit and use a shallow cutting depth, the iModela can cut both accurately and fast. Shallow cuts are also best for creating fine details.

We used a feed rate of around 8mm/second and with the cutting depth set appropriately, the iModela had no problem removing copper at this rate. The cuts were clean and accurate, as you can see from the photos.

In fact you could probably go faster than this. An Arduino shield-sized board (75 x 53mm) of moderate complexity should take less than an hour to mill and drill.

Supplied software

The iModela is supplied with two main pieces of software as well as the Windows driver. The one we found most useful is the iModela Controller. This performs the two most critical functions, which are manual control over the motors and the ability to process G-code files.

Manual axis control is useful for installing a tool, setting the Z-axis height correctly and setting the X/Y origin. These are all important steps before you can proceed with cutting.

G-code files contain a set of commands which, when executed, tell the unit all the movements it needs to make to produce a 3D object. For those familiar with Gerber files (used for PCB manufacture), the formats are similar; both are based on the RS-274D standard.

Normally, the G-code file commands are relative to the origin at (0, 0, 0). For a PCB, this may be the lower-left corner of the design, with the tool just resting on top of the copper.

If you don't set this correctly, it may cut too deep, or fail to cut the copper at all. Or it may start the design in the wrong place on the blank PCB, possibly causing some of it to go off the edge. So clearly, setting the origin is important.

Once the tool is installed and the origin set, you then feed in the G-code file(s) and the iModela starts cutting. During this process, you can see the current position of the X/Y/Z axes, the spindle speed, motor drive power and what line of the G-code file is currently being processed.

You can use this information to track the progress of the job but we would prefer to see some kind of progress bar, time remaining and/or percentage complete indicator.

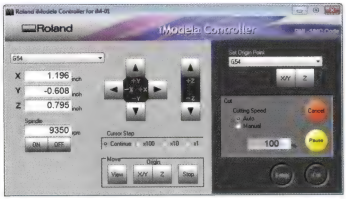
It would also be nice to get some kind of preview, to see how the G-code commands will line up with the work piece. Perhaps these will be added to future editions of the software.

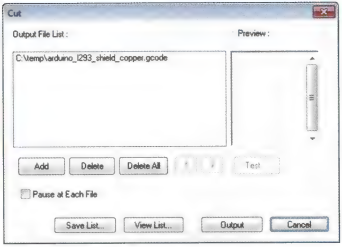
The other piece of software supplied is called iModela Creator and it's a "2.5 dimension" computer-aided modelling program (or 2.5D CAM). It lets you cut and engrave a sheet of material into a particular shape.

The shape is defined using a set of primitives entered into the Creator program such as text, polygons, circles, ellipses and Bezier curves. It can also import Adobe Illustrator files.

Once you have created or imported the 2D outlines of your design, you then have the choice of how to mill them. These are:

* "Pocket", mills out the inside of the shape to a specified depth.





iModela Controller gives manual control of the mill's three axes and the spindle motor. It's also used to feed G-code command files to the iModela (using the Cut button).

* "Engrave", mills the outline and can be configured to cut inside, outside or exactly on the outline itself.

* "Hole", drills or cuts a hole through the material.

* "Cutting", cuts a shape out of the material (like Engrave but going all the way through the material).

Having placed the shapes, you can then move and adjust them until you are happy with the design.

Selecting the "Cut" option then prompts you to select the type of cutting bit, the material being cut and so on and then the iModela spins the tool up and mills your design.

Preparing PCB files

If you want to feed the output of other software to the iModela, your main option is to use G-code files. Generating these from a PCB requires the calculation of an "isolation cut". This involves computing the paths along which to move a tool of a given diameter in order to remove just the copper necessary to separate each copper "island" (or net).

Normally we create a minimal isolation cut, ie, just those cuts required to separate the copper islands while leaving any unused copper in place. This reduces both cutting time and tool wear.

For this review, we used a PCB designed in CadSoft EAGLE, as we expect this is what many readers will want to use in conjunction with the iModela. We deliberately chose a difficult board to mill, with 12 thou tracks and 16-20 thou clearances, to see what the iModela is capable of.

With EAGLE, the best option for generating the isolation cut and G-code file is a free add-on called (wait for it!) PCB-Gcode. Once it's installed, it's quite simple to operate although there are many parameters to set.

PCB-Gcode can generate an isolation cut file, drill file, board outline milling file or some combination of all three. The first step is to select which of these you want and configure the tool diameter and the isolation cut tuning parameters (which you can probably just leave at the defaults).

We had to choose a slightly smaller bit diameter than our actual tool (21 thou rather than 24) because of the fineness of the tracks and smaller clearance we used; otherwise, the software would have left some tracks incorrectly joined. This is why it pays to check the preview.

The next step is to set the spindle spin-up time, feed rates (X/Y and Z), cutting and drilling depth, how high to lift the tool when moving it, where to move the spindle for tool changes (if necessary) and so on.

You can then tweak the G-code style the program is going to generate; some programs can be fussy but we found the iModela software handled the "generic" G-code output just fine.

It's then just a matter of telling PCB-Gcode to generate the G-code files and it does so in no time. Having checked the previews (assuming you enabled them), you can then install your tool, set the origin and feed the G-code files to the iModela Controller software and away it goes.

Milling a PCB

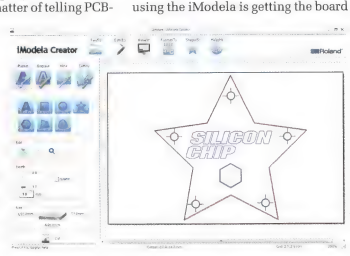
For this job, we used a 0.6mm tungsten carbide spear drill bit. Tungsten carbide does not blunt as quickly as other materials when cutting a fibreglass PCB.

Spear drills can be used for both milling track outlines and drilling component holes – there's no need to change tools.

We acquired a set of two such bits (0.6mm and 0.8mm) with the required 2.35mm shafts for about $16 from Proxxon World (**www.proxxonworld.com.au** SKU 28321).

As you can see from the accompanying photos, the outcome was quite good and the assembled PCB (an SMD version of the MiniSwitcher project from February 2012) works fine.

The hardest part of milling a PCB using the iModela is getting the board



iModela Creator is a simple vector drawing program which allows you to cut, engrave and route various shapes including text. It's easy to use and appropriate for simple jobs.

At left are the 0.6mm and 0.8mm tungsten carbide spear drill bits we used to create our PCB. At right is a packet of tungsten vanadium general purpose routing bits which also suit the iModela.

This small PCB has tracks as thin as 0.012" (0.3mm) and clearances of around 0.02" (0.5mm). With careful adjustment of cutting depth we were able to get a good result.

perfectly flat on the bed. This is more due to the blank PCB stock not being flat in the first place rather than a problem with the iModela itself.

The recommended method of using double-sided tape to secure the work piece to the bed isn't exactly a guarantee of flatness (but we found it worked OK).

First, we laid the edge of a steel rule along the top surface of the PCB, which made its bend obvious. We then gently bent the PCB in the correct direction and repeated until it was more or less flat.

Having done that, we cut out an appropriately sized section (around 85 x 55mm), without bending it too much in the process and filed the edges clean. It's a good idea to re-check the flatness after cutting and fix if necessary.

We stuck one of the flat pieces of plastic provided with the iModela to the bed, using double-sided tape. This made a sacrificial bed and we taped the blank PCB material on top of this and pressed it down hard.

It's possible to use the mill itself to level the bed under the PCB, ensuring it's perfectly flat (relative to the X/Y axes) but we reckoned it was flat enough to start with so we didn't bother.

The next step was to insert the 0.6mm spear drill bit in the "chuck". Ideally, we would then just let it drop onto the PCB surface, tighten the grub screw and zero the Z-axis origin in the iModela Controller software.

This sets the unit up so that positive Z-axis coordinates result in a cut while negative coordinates allow the tool to move without touching the PCB. We had already set up the PCB-Gcode Z-axis co-ordinates to use this system, which makes the G-code files independent of the tool and bed set-up.

At this stage, we encountered one minor wrinkle in that the spear drill shafts are relatively short and combined with the limited Z-axis travel of the iModela (about 26mm), they didn't reach the PCB when pushed all the way up into the tool holder. We had to drop them down quite a bit and even then they only just reached, but we couldn't lower them any further since they still had to be engaged by the grub screw.

In the end it worked OK but this is something for iModela owners to look out for – you will need tools with reasonably long shafts or else you will need a thicker sacrificial bed, to lift the PCB or other work piece up to meet the cutting tool.

Having set up the Z-axis, we then proceeded to move the tool to the position where we wanted the lower-left corner of the design to be cut and set the X/Y origin there. If your design is much smaller than the iModela's working area, this is a convenient way to be able to mill multiple copies (or make multiple attempts).

You don't want the origin to be right in the corner of the cutting area as the tool needs to be able to cut around the lower-left most track (depending on where the origin is in your PCB design).

This is a bit of a "gotcha"; if you try to rout a board where the G-code commands try to go outside the iModela's limits, it simply skips the portion of the commands which it can not execute. This will probably leave you with an incomplete result and you won't get any warning until it happens.

For this reason, it's probably worthwhile visually checking the G-code text file for negative co-ordinates before you start.

Anyway, we'd set up everything as best we could but just to be sure, we re-set the Z origin to be slightly above the PCB surface and then fed in the G-code file.

We were then able to watch the iModela go through the motions while not actually cutting the PCB. Satisfied it was all correct, we lowered the Z-axis slowly in increments and re-started the job until it was cutting deep enough to go through the copper layer without going too far into the fibreglass.

At that point we left it to finish milling the board.

Once it's finished, you can open up the plastic panels which contain the swarf. Don't open them while it's cutting; it may be unlikely but we wouldn't risk being hit in the eye! It's then just a matter of removing the PCB from the bed that it's taped to and cleaning out the dust and swarf.

The result is shown here. We have no doubt that it's possible to mill a full-sized Arduino shield using this method but you would certainly need to be careful to ensure the PCB is nice and flat.

Conclusion

The iModela is easy to use and can make accurate cuts. It is capable of good results when used with soft materials (eg, plastic) and when milling PCBs. It is compact, portable and cheaper than virtually any other prebuilt CNC mill on the market.

It does have some drawbacks; its lack of a proper chuck or collet to hold the tool is unfortunate and the bed size, Z-axis travel and spindle motor power are a bit limited.

Having said that, the iModela doesn't really have any direct competitors and it certainly is a good way to get into CNC machining.

For making small PCBs, we like the fact that there are no chemicals involved and once you get the hang of it, it's a relatively quick and easy process to go from the design stage to having a finished prototype board.

Price & availability

The iModela is available from Roland DG Australia for under $1000, including GST.

They also sell accessories such as cutting tools, replacement spindle motors and wood-based blanks for cutting.

For more information, visit their website at rolanddg.com.au and search for "imodela" or call either their Sydney office at (02) 9975 0000 or Melbourne at (03) 8873 3300. SC

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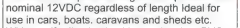

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This kit comes with all parts required and includes cables and connectors. The driver's display shows distance (max 2.5M) via a 7 segment display, left & right LED bar-graphs and audible alarm. The distance displayed is surprisingly accurate and has a 100mm resolution. Paint and moisture don't seem to bother the sensors and the radar will work with 1, 2, 3 or 4 sensors. [K304] $35

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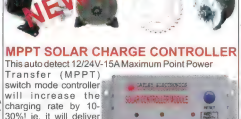

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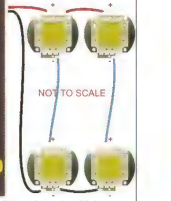
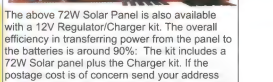


Don't let the price fool you, these is a high quality solar panels and LEDs. Inc. one "First Solar" brand FS-272 72W/66V/12KG Panel + 4 20W-34V-0.7A LED's. The LEDs are connected in series/parallel & will require some heatsinking, they give a total of OVER 5000 LUMENS! This system is self regulating, simply connect the panel to the LEDs. The Cadmium Telluride (CdTe) cells are sandwiched between 2 sheets of glass with rounded, polished edges, they are totally sealed and waterproof & have better performance at higher temperatures & in lower light.

72W SOLAR PANEL WITH A 12/24V REGULATOR CHARGER KIT



The above 72W Solar Panel is also available with a 12V Regulator/Charger kit. The overall efficiency in transferring power from the panel to the batteries is around 90%. The kit includes a 72W Solar panel plus the Charger kit. If the postage cost is of concern send your address and contact details and / or an order by email to: branko@oatleyelectronics.com
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Vintage Radio

By Associate Professor Graham Parslow

A "vintage" radio from just a front panel

It's not really an authentic vintage radio but this resurrected radio could almost pass for the real thing. It all started with a front panel from the 1930s but it now hides transistors, not valves.

THERE'S A WAY to win vintage radios at an auction – you simply pay more than anyone else is prepared to. At first, that's exactly what I did, by making liberal bids on eBay. So in 2007, I won the lot of radios shown in the photo above for $385. The 1938 STC model 500-I (middle radio) was a must-have and I would be quite happy to pay $300 for one of these in good condition.

The radios were on a farm 200km out of Melbourne. Bob, who sold me the radios, turned out to be a typical affable country person and offered to bring the lot down in his ute on the next trip to Melbourne. We hit it off rather well when he made the delivery and we chatted quite bit.

The radios were in appalling condition and after Bob left I had a quiet moment of reflection on the value of my purchase. In marketing terms, this is known as "buyer's remorse".

Relieving the remorse

Some of my despondency was quickly relieved by simply getting a hose out and washing the chicken droppings off the 1946 Breville (the righthand-side radio in the photo). This was a radio that I did not personally value highly, so I was prepared to be a bit cavalier about how I treated it. But there are a number of reasons why hosing down a plywood radio from the 1940s is a bad idea, including delamination of the ply and staining.

In this case I was luckier than I deserved to be and that Breville still remains reasonably intact on a shelf waiting for me to restore it. That's the thing about projects; they get done when you make time.

There is no great ledger saying you have free time and this is what you will do; projects get chosen by your motivation at the time and my highest initial motivation was to restore the STC. That restoration had a great outcome and when I subsequently showed Bob pictures of that STC radio, he called it wizardry.

One of the great things about restorations is that they are not only personally satisfying but also a means of sharing an interest with other people. Bob told me that the radios I bought

This L-shaped timber piece consisting of an ornate front panel (complete with metal escutcheon) and baseboard was the starting point for the project. It was probably made around the early 1930s.

The baseboard was in quite poor condition, due to delamination of the plywood and was subsequently discarded, leaving only the front panel and the escutcheon.

attracted quite a few questions during the auction, mostly about the facade panel (top of the pile in the photo). It subsequently spent a couple of years in my storage shed in a prominent place that I constantly walked past.

One day, it attracted my attention and the decision was made to make this the next project. This was appropriate since by that time my knowledge of the history and technology had become better honed, along with my technical restoration skills.

Personal background

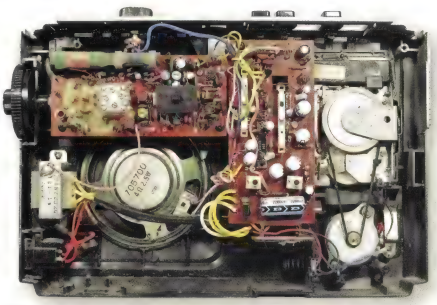
I was born in 1948 and raised in a small country town in South Australia. As a boy, I made crystal sets, tinkered with simple electronic circuits and avidly read *Radio, Television & Hobbies*. I brought home radios scavenged from the local tip (mostly from the 1940s) and took them to pieces.

When I began collecting radios in my 50s, they were mainly the radios of my early years, both valve and transistor. As my collection grew, I became more systematic in reading the history of radio. This took me back to the 1920s and the dawn of commercial radio transmissions, encouraging the acquisition of some 1920s sets, both commercial and hand-made.

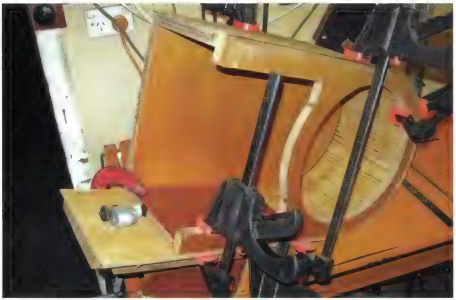
These 1920s radios universally conform to the coffin style: a rectangular box (wood or metal) with knobs and connections for batteries, aerial and speakers or headphones. The commercial radios of the 1920s made a great feature of the tuning indicator escutcheon. These were typically made of brass and sometimes included an enamel badge, as does the mantel radio featured in this article.

The calibrated tuning dial was usually graduated from 0-100 and listeners would write down the numbers for their favourite stations. As more stations became available and manufacturers were better able to align their radios consistently, they printed the station call-signs on the dial, a feature much preferred by buyers.

By the end of the 1920s, it was evident that headphones were no longer suited to a family radio and the speakers were routinely incorporated in the radio cabinet, rather than independently standing on top of it. The



The tuner, audio amplifier and power supply modules were transplanted into the vintage cabinet from this old Sanyo radio-cassette player.



The 3-ply outer sheath was shaped by making multiple kerfs into the reverse side of the ply, so it could be formed to the semicircular dome shape required.

natural outcome of this evolution was the cathedral style of radio, spanning roughly 1928-1935.

The starting point

As shown in the photos, the remarkably sparse starting point for this particular project was an L-shape of two wooden panels (face and base), with some moulding around the base. Most restorers would place this fragment of a once proud radio in a corner of the shed or even throw it out but I saw it as an inspiring cornerstone to a unique project.

Ideally, every bit of the original material would be incorporated into the final product, although that was not the outcome here. Step one was simply to put it on the bench and engage the power of imagination. The constraints were to produce a radio that not only looked original but which also used what was already on hand in my salvage bins if at all possible.

It was apparent the knobs had to remain where the four holes were but nothing I had in my salvage shelves lined up at all well with those holes. However, the project eventually came to fruition after I made a large acquisition of 1980s boom-boxes and cassette-radios. As an aside, I hope that these icons of the 80s become collectable sometime soon because then I will have a valuable asset rather than what my wife insists they are, ie, junk.

Be that as it may, an old Sanyo radio-cassette player which no longer functioned on the FM band was not going to be missed. It was effectively constructed using three separate modules: power supply (with mains transformer), tuner and audio amplifier.

Immediately, the possibilities were evident, especially as the tuning capacitor was driven by a simple pulley-wheel and the discrete volume pot was separate from the circuit boards.

Putting it together

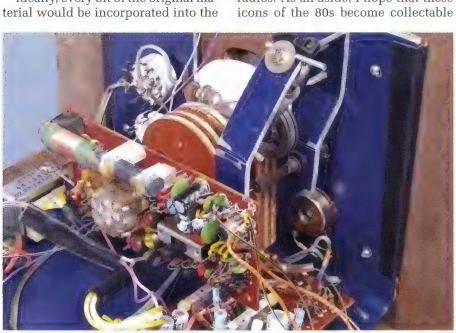
So the project was conceived as a dedicated AM receiver with four knobs controlling On-Off, Volume, Tuning and Tone (top-cut). My metal-bits box contained the case of what was once an LKB electrophoresis power supply and it provided a heavy-gauge aluminium bracket to anchor the electricals. The aim was to anchor the frame only to the front panel and this was simply done by using wood screws from the back.

Once the four holes were in place for the knobs and a cut-out provided so that the tuning dial could be viewed through the escutcheon, the project rapidly progressed to the point of functioning. My knobs box had only one radially-calibrated dial that I could use as the tuning indicator and this was scanned and reproduced onto thin cardboard that would allow back-illumination by a dial globe.

My knobs bin didn't include a set of four matching knobs that were genuine 1930s, so four instrument knobs with pointers from the 1950s were selected, initially to see what it would look like. It looked modestly acceptable so the pointers were removed from the knobs and they remained part of the project.

Happily, a 12-inch (300mm) Magnavox speaker I bought in the 1970s fitted snugly into the cathedral speaker space.

At this stage, apart from some screw holes at the rear, no physical alteration had been made to the casing. The original radio was manufactured by A. J. Veall Pty Ltd who were located at 243 Swanston Street, Melbourne, until they relocated to Bridge St, Richmond in 1954. They traded in a range of electrical goods and in this respect they were comparable to retailers like Myers and Malvern Star, who sub-



The power supply, tuner and audio amplifier modules from a old Sanyo radio-cassette player form the heart of the resurrected "vintage" radio.

This view shows the general assembly. The electronic modules were mounted on an L-shaped aluminium bracket, while a 300mm Magnavox loudspeaker from the 1970s fitted snugly into the cathedral speaker space.

The completed radio looks just like the 1930s original but there are no valves inside the cabinet – just a solid-state transplant that's not only more reliable than the original but sounds better as well.

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The refurbished "vintage" radio now looks quite at home in the lounge room, where it is once again serving as a family radio.

contracted out for radios to be made to sell as a house brand.

In fact, it's likely that this mantel radio was a house brand with limited production, because a web search failed to find any reference to the brand.

The radio boom

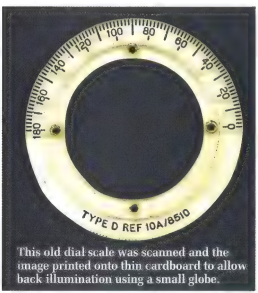
Radio was a new boom in the 1930s, driven locally by the resolution of royalties for patents so that all comers could use the superior superhet design through the ARTS&P system in Australia. This meant that small companies could make their own radios, free from prosecution for design infringements, by sub-contracting to a cabinet maker and a radio chassis fabricator.

This cottage industry was destroyed by World War 2, for a number of reasons. When a mantel radio sold for around 30 pounds, it became the pride of the lounge-room as it probably cost six months of hard-earned savings in the era of the Great Depression.

For a manufacturer, it was worth paying a pound extra to the cabinet maker to use mixed veneers, inlay some ebony and perform some fine fret-work to incorporate a "fleur de lys" design into the speaker opening.

After 80 years, many of them in a country shed, my object of 1930s craftsmanship displayed many cracks in the aged veneer. However it did remain largely intact due to the good coat of shellac it started with.

So what to do with the wood-work? Some hard decisions were needed and the result was to discard the two lengths of damaged moulding around the base, because it was easy to purchase a new length of similar moulding. The baseboard was also quite poor, due to delamination of the plywood, so this too was discarded, leaving only the front panel and the escutcheon to become part of the end result.



This old dial scale was scanned and the image printed onto thin cardboard to allow back illumination using a small globe.

Veneered 5-ply was adequate for replacing the base and for making a frame to hold a 3-ply outer sheath. The professional way to mould plywood is by using steam but I set up my saw bench to make multiple kerfs into the reverse side of the ply, so it could be formed to the semicircular dome shape required. With suitable gluing and screwing, the case was made ready for the finishing touches.

Remarkable results with timber finishing have been achieved for centuries using natural products. By luck more than design, Bayer in Germany were looking for a Nylon-like polymer to avoid DuPont patents when they discovered polyurethanes which they patented in 1937.

Purists may revel in using original finishes but I am happy to use modern finishes with all their advantages of hardness, transparency and lustre. However, I quickly learned from previous restorations that the old finishes react badly with polyurethanes and the first step must be to reach for the paint stripper and meticulously clean the cabinet back to the bare timber.

The first finishing step for the Mantel was to paint over the exposed edge surfaces with a brown acrylic paint that matched the original paint. The face and case were separately painted with polyurethane, so that the junctions did not fill. The first coat was applied using solvent-diluted polyurethane with a brush to ensure that the raw wood was adequately wetted and penetrated.

This was followed by eight or so applications of Wattyl Estapol from spray cans. For a job of this size, it's inefficient to set up a compressor and spray gun, however a brush used for finishing coats is counter-productive, with marks inevitably remaining obvious in the hardened surface. So multiple thin coats were carefully sprayed on and sanded back.

Patience is essential at this stage to allow each sparsely applied coat to thoroughly dry before sanding back. The very last addition to the mantel was some speaker grille cloth. Then with some satisfaction it was taken to the lounge room and is now again serving as a family radio.

The bass is rich and speech is clear. What's more, the authentic 1932 characteristics of 50Hz background hum and delayed warm-up are features that I am happy to forego. SC

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UHF ROLLING CODE RECEIVER	AUG 2009	15008092	$45.00
6-DIGIT GPS CLOCK AUTODIM ADD-ON	SEPT 2009	04208091	$10.00
STEREO DAC BALANCED OUTPUT BOARD	JAN 2010	01101101	$25.00
DIGITAL INSULATION METER	JUN 2010	04106101	$25.00
ELECTROLYTIC CAPACITOR REFORMER	AUG 2010	04108101	$55.00
ULTRASONIC ANTI-FOULING FOR BOATS	SEP 2010	04109101	$25.00
HEARING LOOP RECEIVER	SEP 2010	01209101	$25.00
S/PDIF/COAX TO TOSLINK CONVERTER	OCT 2010	01210101	$10.00
TOSLINK TO S/PDIF/COAX CONVERTER	OCT 2010	01210102	$10.00
DIGITAL LIGHTING CONTROLLER SLAVE UNIT	OCT 2010	16110102	$45.00
HEARING LOOP TESTER/LEVEL METER	NOV 2010	01111101	$25.00
UNIVERSAL USB DATA LOGGER	DEC 2010	04112101	$25.00
HOT WIRE CUTTER CONTROLLER	DEC 2010	18112101	$25.00
433MHZ SNIFFER	JAN 2011	06101111	$10.00
CRANIAL ELECTRICAL STIMULATION	JAN 2011	99101111	$30.00
HEARING LOOP SIGNAL CONDITIONER	JAN 2011	01101111	$30.00
LED DAZZLER	FEB 2011	16102111	$25.00
12/24V 3-STAGE MPPT SOLAR CHARGER	FEB 2011	14102111	$15.00
SIMPLE CHEAP 433MHZ LOGATOR	FEB 2011	06102111	$5.00
THE MAXIMITE	MAR 2011	06103111	$25.00
UNIVERSAL VOLTAGE REGULATOR	MAR 2011	18103111	$15.00
12V 20-120W SOLAR PANEL SIMULATOR	MAR 2011	04103111	$25.00
MICROPHONE NECK LOOP COUPLER	MAR 2011	01209101	$25.00
PORTABLE STEREO HEADPHONE AMP	APRIL 2011	01104111	$25.00
CHEAP 100V SPEAKER/LINE CHECKER	APRIL 2011	04104111	$25.00
PROJECTOR SPEED CONTROLLER	APRIL 2011	13104111	$10.00
SPORTSYNC AUDIO DELAY	MAY 2011	01105111	$30.00
100W DC-DC CONVERTER	MAY 2011	11105111	$25.00
PHONE LINE POLARITY CHECKER	MAY 2011	12105111	$10.00

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	CODE:	Price:
20A 12/24V DC MOTOR SPEED CONTROLLER MK2	JUNE 2011	11106111	$25.00
USB STEREO RECORD/PLAYBACK	JUNE 2011	07106111	$25.00
VERSATIMER/SWITCH	JUNE 2011	19106111	$25.00
USB BREAKOUT BOX	JUNE 2011	04106111	$10.00
ULTRA-LD MK3 200W AMP MODULE	JULY 2011	01107111	$25.00
PORTABLE LIGHTNING DETECTOR	JULY 2011	04107111	$25.00
RUDDER INDICATOR FOR POWER BOATS (4 PCBs)	JULY 2011	20107111-4	$80 per set
VOX	JULY 2011	01207111	$25.00
ELECTRONIC STETHOSCOPE	AUG 2011	01108111	$25.00
DIGITAL SPIRIT LEVEL/INCLINOMETER	AUG 2011	04108111	$15.00
ULTRASONIC WATER TANK METER	SEP 2011	04109111	$25.00
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ULTRA-LD MK3 AMPLIFIER POWER SUPPLY	SEP 2011	01109111	$25.00
HIFI STEREO HEADPHONE AMPLIFIER	SEP 2011	01309111	$45.00
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QUIZZICAL QUIZ GAME	OCT 2011	08110111	$30.00
ULTRA-LD MK3 PREAMP & REMOTE VOL CONTROL	NOV 2011	01111111	$35.00
ULTRA-LD MK3 INPUT SWITCHING MODUL	NOV 2011	01111112	$25.00
ULTRA-LD MK3 SWITCH MODULE	NOV 2011	01111113	$10.00
ZENER DIODE TESTER	NOV 2011	04111111	$20.00
MINIMAXIMITE	NOV 2011	07111111	$10.00
ADJUSTABLE REGULATED POWER SUPPLY	DEC 2011	18112111	$5.00
DIGITAL AUDIO DELAY	DEC 2011	01212111	$30.00
DIGITAL AUDIO DELAY FRONT & REAR PANELS	DEC 2011	01212112P2/3	$20 per set
AM RADIO ANTI-SUPPRESSOR	JAN 2012	06101121	$10.00
STEREO AUDIO COMPRESSOR	JAN 2012	01201121	$30.00
STEREO AUDIO COMPRESSOR FRONT & REAR PANELS	JAN 2012	01201121P1/2	$20.00
3-INPUT AUDIO SELECTOR (SET OF 2 BOARDS)	JAN 2012	01101121/2	$30 per set
CRYSTAL DAC	FEB 2012	01102121	$20.00
SWITCHING REGULATOR	FEB 2012	18102121	$5.00
SEMTEST LOWER BOARD	MAR 2012	04103121	$40.00
SEMTEST UPPER BOARD	MAR 2012	04103122	$40.00
SEMTEST FRONT PANEL	MAR 2012	04103123	$75.00
INTERPLANETARY VOICE	MAR 2012	08102121	$10.00
12/24V 3-STAGE MPPT SOLAR CHARGER REV.A	MAR 2012	14102112	$20.00
SOFT-START SUPPRESSOR	APR 2012	04104121	$10.00
RESISTANCE DECADE BOX	APR 2012	04105121	$20.00
RESISTANCE DECADE BOX PANEL/LID	APR 2012	04105122	$20.00
1.5kW INDUCTION MOTOR SPEED CONTROLLER	APR 2012	10105121	$35.00
HIGH TEMPERATURE THERMOMETER MAIN PCB	MAY 2012	21105121	$30.00
HIGH TEMPERATURE THERMOMETER F&R PANELS	MAY 2012	21105122/3	$20 per set
MIX-IT! 4 CHANNEL MIXER	JUNE 2012	01106121	$20.00
PIC/AVR PROGRAMMING ADAPTOR BOARD	JUNE 2012	24105121	$30.00
CRAZY CRICKET/FREAKY FROG	JUNE 2012	08109121	$10.00
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WIDEBAND OXYGEN CONTROLLER MK2 DISPLAY BOARD	JULY 2012	05106122	$10.00
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PIC12F675	UHF Remote Switch (Jan09), Ultrasonic Cleaner (Aug10), Ultrasonic Anti-fouling (Sep10), Cricket/Frog (Jun12), Barking Dog Blaster (Sept12)
PIC16F1507-I/P	Wideband Oxygen Sensor (Jun-Jul12)
PIC16F88-E/P	Projector Speed (Apr11), Vox (Jun11), Ultrasonic Water Tank
PIC16F877A-I/P	6-Digit GPS Clock (May-Jun09), Lab Digital Pot (Jul10) Semtest (Feb-May12)
PIC18F2550-I/SP	Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10)
PIC18F4550-I/P	GPS Car Computer (Jan10), GPS Boat Computer (Oct10)
PIC18F14K50	USB MIDIMate (Oct11)
PIC18F27J53-I/SP	USB Data Logger (Dec10-Feb11)
PIC18F27J53-I/SO	Sound Effects Generator (Sept12)
PIC18LF14K22	Digital Spirit Level (Aug11), G-Force Meter (Nov11)
PIC18F1320-I/SO	Intelligent Dimmer (Apr09)
PIC32MX795F512H-80I/PT	Maximite (Mar11), miniMaximite (Nov11)
PIC32MX695F512L-80I/PF	Colour Maximite (Sept12)
dsPIC33FJ128GP802-I/SP	Digital Audio Signal Generator (Mar-May10), Digital Lighting Controller (Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11) Level (Sep11), Quizzical (Oct11), Ultra-LD Preamp (Nov11)
dsPIC33FJ64MC802-E/SP	Induction Motor Speed Controller (Apr-May12)
ATTiny861	VVA Thermometer/Thermostat (Mar10), Rudder Position Indicator (Jul11)
ATTiny2313	Remote-Controlled Timer (Aug10)
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Prices include GST and are valid only for month of publication of these lists; thereafter are subject to change without notice. *Note: P&P is extra ($10 per order in Australia).
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ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Write to: Ask Silicon Chip, PO Box 139, Collaroy Beach, NSW 2097 or send an email to silicon@siliconchip.com.au

Changing shunt for battery charge monitor

I would like to ask a few questions about the June 2008 battery charge monitor. Can the shunt be mounted remotely from the unit, say 2m away using shielded cable? Can a higher value current be measured using a 150A shunt (>.0334Ω)? We have a 110A alternator with an intelligent regulator that allows the full 110A to be delivered to our 1000Ah battery bank. (R. F., via email).

● The shunt can be located away from the charge monitor. The leads back to the charge monitor should be shielded by using heavy-duty microphone cable. The shunt can be changed to a lower resistance to suit the higher current, as you suggest.

Speed control is not progressive

I recently purchased a Full Wave Mains Motor Controller (SILICON CHIP, May 2009) from our local Jaycar Electronics store. After assembly and testing of the kit, a problem became apparent. When adjusting the speed control using speed potentiometer VR1, the actual speed of the attached jigsaw varied from zero to about 10% in a smooth progression and then jumped to full speed for the rest of the adjustment range.

I have made several adjustments to trimpot VR2 without any effect on the speed control operation. Could you please advise me on how I can rectify this problem? (A. B., via email).

● It seems likely that trimpot VR2 has an open-circuit wiper. Check that you can vary its resistance down close to zero ohms.

Note that power must be switched off and the mains plug unplugged from the mains outlet before removing the lid and doing this check.

Flat battery should not cause data loss

I have the 3-Channel Rolling Code UHF Remote Control (SILICON CHIP, August & September 2009). It has been in use for around two years, very successfully. Recently, two of the remotes have stopped working due to flat batteries. I replaced the batteries but they still would not work. The third remote is still working, although the battery is low.

On this transmitter, I connected a 9V battery with small crocodile clips to the battery terminals to retain power, swapped the 12V battery and removed the "jumper" battery. This third Tx still works OK with the new 12V battery. I'm assuming this means that every time the battery goes flat in one of the transmitters you either have to provide a "jumper" battery BEFORE the internal battery goes flat or re-assign the transmitter to the receiver after every battery change. This is a pain as the receiver is not easily accessible. Any suggestions? (P. C., via email).

● Removal of the battery should not affect the transmitter, as all necessary data for rolling code transmission is stored in EEPROM and so is not lost with loss of power. The microcontroller does not rely on the volatile RAM to store the rolling code data on each switch press.

It's possible that the battery was so flat that a switch press caused the rolling code to change but there was insufficient power to allow the EEPROM to be written to correctly.

Test query on motor speed controller

Recently, I successfully completed the Motor Speed Controller (SILICON CHIP, June 2011). The instructions indicate potentials to be achieved at the test points when operating with a 12V DC supply. I have been asked to connect the circuit to a 24V DC source. How will this affect the potentials at the test points? (L. C., via email).

● All the test point voltages between TP1 & TP2, TP3 & TP4 will be the same whether the supply is 12V or 24V. That is because the test points are for voltages following the 12V regulator. For TP5 (which measures the low bat-

Power Supply For Underwater Scooters

I am rebuilding some underwater scooters (diver propulsion vehicles) which will be used to depths of 100m and travelling distances of up to 10km in caves. I need a controller that can operate from 24V (30V max.) and is capable of up to 25A continuous (45A peak) with soft start. I need five speed settings, adjusted by a momentary on/off switch on the fly (each ON cycles to the next preset speed until the highest, then reverts back to the lowest level).

Other features of the unit would include a separate trigger/dead-man switch, back-EMF to monitor for jams, controller protection (over current and over temperature), a display to show supply voltage and load if possible and an LCD. (R. M., via email).

● You could base the design on the DC Motor Speed Controller published in the March & April 2008 issues. A preset switched speed control could be made using a 4017 counter with the input switch triggering the counter, one count at a time. The sixth output (output 5) would connect to the reset input so that it cycles through five different settings.

The outputs of the 4017 should be connected to different-value resistors via series diodes. The other ends of the resistors are then tied together and connected to another resistor which goes to ground, to form a variable voltage divider.

tery cut-out voltage), we described the procedure for setting up when using a 24V supply, using VR4. This is described under the Low-Voltage Cut-out cross heading.

LCD has black blocks

I have built the Digital LC Meter from the May 2008 issue. On power-up, the LCD screen only shows a line of blocks of square dots. I have carefully checked everything with nothing obvious, the PIC16F628A programmed "No Fault", and all power and grounds as per circuit diagram check OK. What possible further checks I can do? (N. Q., via email).

● A line of black blocks on the LCD suggests that the module is not being set up correctly. This could be due to an open circuit line or short circuit on the D4-D7, RS or EN lines. Check the solder joints, PCB tracks and IC sockets carefully for faults.

It's also possible that the module is particularly "slow on the uptake" during the initialisation sequence. Like all other firmware programs designed to work with an LCD, the one for the LC meter of May 2008 includes quite significant delays in the initialisation sequence. However it may be that these delays are not quite enough for your particular module.

If that's the case, you can increase the delays in the initialisation routine, which you'll find in the source code labelled "LCDINIT". In particular, change the first line from CALL MS200 to CALL MS300 and then change the sixth line from CALL MS100 to CALL MS200.

If you then assemble the program again and reprogram the PIC with the new hex code, this will hopefully fix your problem.

Wireless link to smart meter

My year old smart meter has a red LED that flashes every ~0.3Wh with consumption. Would an optical sensor linked wirelessly to a home base logger be possible? My quarterly bills now show consumption to 0.001kWh rather than the previous 10kWh. (J. W., via email).

● Have a look at the Circuit Notebook item on page 58 of the July 2012 issue. That is the exact solution.

A Variac Cannot Control Induction Motor Speed

I was very interested in your article in the April and May 2012 issues about the Induction Motor Speed Controller. In the April article, Andrew Levido notes that the only way of controlling induction motor speed is to vary the drive frequency. To understand this more, I connected my pool pump (Davey SLS200, 1090 watts, 330 l/min max flow rate) to the mains through a Variac and a commercial power meter.

As I wound the Variac back, the speed of the pump motor certainly dropped, in quite a smooth but not linear way, until it stopped when the applied voltage fell to 133VAC. These are the somewhat surprising results:

Variac Setting	Motor Volts	Current (A)	PF	Power (W)
100%	240.5	5.1	0.87	1066
90%	208	5.6	0.91	1057
80%	165	8.0	0.85	1155
70%	133	8.4	0.75	833

I have no way of recording motor speed or pump flow/pressure but the test confirms that although pump speed can be controlled by a simple voltage reduction, the power consumed by the motor remains approximately constant down to quite low speeds. To prove the economic feasibility of your controller, could you please perform similar tests to mine, noting the actual power in watts being consumed as a function of speed and flow rate and/or pump delivery pressure.

The approximate cost of the controller is also needed. An earlier review of a pool-pump controller had a price tag of over $1000. At that price, the pay-back time to recoup the cost from power savings is excessive. To make your project even more attractive to the misers out there, a future magazine comment which explains just why Variac control is not practical would be helpful. In my view, if a simple payback period is more than one year, then the investment is probably not viable.

Incidentally, have you measured the RFI generated by the controller to confirm it complies with relevant standards? (R. F., McCrae, Vic).

● As can be seen from the first article in April, the Speed Controller will control induction motors over a very wide range, from very slow to about 50% faster than normal operation. Your Variac will control the speed but only over a narrow range and as you have found, the power consumption is hardly reduced at all so there is no point in doing it. After all, the reason for building it to run a pool pump is to get a good saving in energy cost.

Jaycar has made a kit available, priced at $229. (Cat. KC-5509). That is probably less than the price of a suitably-rated Variac which, as already noted, does not work.

If you want to get a handle on the likely savings when using the Induction Motor Speed Controller with a pool pump, have a look at the review we did on the FutureWave controller in the June 2011 issue. It gave major power savings. An investment of $229 in our controller is likely to be paid back in less than a year.

By the way, for many readers who do not wish to build our controller, we still regard the FutureWave pump controller as a very good investment since it does give major power savings and is easy to install. Our design does comply with relevant standards. In fact, it produces less EMI than the FutureWave unit.

Question on loudspeaker phasing

I am attempting to locate an article on "speaker phasing" and to establish if a kit is available. Can you help? (J. S., Redcliffe, NSW).

● If you simply want to know about connecting loudspeakers to an amplifier and keeping each loudspeaker in-phase, then the wiring should be the same polarity from the amplifier to the loudspeakers for the left and right channels and also for the centre and surround speakers if used.

As a convention, when a positive

Missing Pin 1 Notch On ICs

I have a problem and have tried to sort it out by referring to data on the internet. However, I have not solved it. I built up a Stereo Compressor kit (Silicon Chip, January 2012) and found that the TL071 chip had no indent to identify pin 1. I have a reasonable electronics knowledge so I sorted the problem out myself.

Firstly, I had a good look at the TL072 and found it had the identifying indent and it also had a round indent which was on the pin 1 end. The TL071 also had this round indent. I installed all three ICs using the round indent in the same configuration and backed this up by applying a very low voltage to start. There was no excessive current as I wound up to the 5V point.

The unit seemed to work so I carried on with testing. I then found the SA571 was only working on one channel. This was checked out and the fault seemed to be in the IC. I wrote to the suppliers telling them of the two faulty ICs and have received back all three of the TL071 and TL072. The joke is that the three replacement ICs do not have the normal identifying indent. I find it strange that the supplier has sent replacements that ALL have, what I am referring to, as a fault.

On your own diagrams of the assembly, you show the indent but not the round top surface marking. My problem is that I cannot find any data sheet that shows any change in the way IC pin 1 is identified and to make it worse, the replacements are faulty too. (L. W., via email).

● Quite a few ICs these days do not have a notch at one end. Our diagrams normally show both a notch and a dimple (shiny spot), either of which indicates pin 1. It's up to the manufacturer as to which method is used.

We checked our prototype Stereo Compressor and the TL071/072 chips have a shiny spot near pin 1. This should be clearly visible under a magnifying glass.

signal voltage is applied between the red (plus) and black (minus) terminals on a loudspeaker, that will cause the speaker cone to move outward. We have not published a project associated with loudspeaker phasing.

No PWM from charger controller

I purchased the 12V Battery Charge Controller (Silicon Chip, April 2008) from Altronics. The microprocessor is drawing 50mA (should be about 10mA) and none of the LEDs driven by the microcontroller are being turned on.

The PWM (pin 9) output is not pulsing, even though AN2 (pin 2 of the microprocessor) is at 4V, LK1, LK3 & LK5 are in and VR1 is fully clockwise. MCLR (pin 4) is at 5V and RB5 (pin 11) is open-circuit. (R. S., via email).

● You may have problems apart from the IC. Firstly, check that transistors Q2 and Q3 are correctly placed. Check that Q2 is a BC337, Q3 is a BC327 and Q4 is a BC327.

Having Q2 and Q3 transposed on the PCB would mean increased current draw and no PWM signal.

Also check the voltage at TP1. With VR1 clockwise, the voltage should be around 1.8V. Check the orientation of the LEDs. The flat side of the LED body (cathode) should be to the right for each LED on the PCB.

Programmable ignition for turbo engines

I am after some information on the Programmable High Energy Ignition kit. Can they be used in a turbo application? (J. M., via email).

● The Programmable Ignition (Silicon Chip, March, April & May 2007) can be used with turbo engines. There is not really any difference in building the programmable ignition for turbo engines compared to naturally-aspirated engines.

The MAP (Manifold Absolute Pressure) sensor that measures engine load needs to suit the turbo boost. So a 2-bar MAP sensor is usually required instead of a 1-bar sensor as used in naturally-aspirated engines.

You would need to map the ignition timing against the output of the MAP sensor for boost and non-boost running against engine RPM.

Off-grid solar queries

Having followed the many letters and articles provided by readers, Silicon Chip magazine itself and various subject matter experts on the subject of solar domestic electricity generation, I can see that there is a minefield of issues, both technical and social, associated with this area of technology. These articles have been a great education as to how a simple concept can have so many ramifications and frustrations to all those involved.

However, having said this, being an avid technology buff I would love to have a play with setting up my own isolated grid at my metropolitan location just for the fun of it. Having noticed how solar panels and inverters have been falling in price, I'm thinking that maybe now is the right time to get my hands dirty.

I'm not talking about a grid-connected system and all the issues and paperwork that goes with it. I'm just thinking about a system that produces 230VAC when the sun shines and is available via my own separate grid made up of extension leads and power boards to start with. Around my home I have a collection of electrical appliances that do not need permanent mains availability and could happily perform their normal functions with only a few hours of mains being made available to them. A few examples are my pool pump, salt-water chlorinator, laptop computers, mobile phones and even the washing machine.

Ideally I would probably like to start with an inverter that is capable of providing one or two kilowatts continuously but will come to life with one or two low-powered panels (say 10 or 20 watts). This might only be sufficient initially for the small items around the house like phone chargers but it gets the foot in the door, so to speak.

A couple of birthdays, Christmases and Fathers' Days later, the system could be enhanced with some extra 120W panels. Add a Silicon Chip project like the March 2012 revised MPPT charge controller and some battery capacity could be added to enable permanent operation.

So where do I start? This is where I would like to hand it over to the experts to provide input and comment on how to set up an entry level off-grid system that can be grown over time

Power Supply Earthing Confusion

I've just built the Dual-Tracking Power Supply (June 2010) and it works fine, except I cannot get the 5V on the front-panel terminals. I've looked at the circuit and I can't see how the earthy side of the 5V terminals is connected to the main board earth. I notice the 5V terminal is marked as a "chassis" ground on the circuit but the 0V point for the dual output and everything else is a "PCB" earth.

As far as I can see, they don't connect! Am I missing something here or can I just connect the two earths without prejudicing the regulation or current sense or causing some unseen disaster? (P. R., via email).

- The outputs of the power supply are "floating" with respect to earth. This includes both the tracking outputs and the +5V output. Both of these are referred to the black terminal, at 0V, which is not necessarily at earth potential.

The green terminal is connected to mains earth. You can indeed connect the black (0V) and green (earth) terminals together if you want. This simply sets 0V = earth and the other terminals are then relative to this voltage.

The problem is that you are connecting your circuit between the 5V output which is floating with respect to earth and the earth terminal. Thus no current will flow.

You can just use the black terminal for 0V instead (this is the ground for both the 5V and the tracking outputs) or if you prefer, you can connect the ground and earth terminals and then use the earth terminal as your 5V ground reference. However, then the outputs would no longer be floating. This is only an issue if the circuitry you are powering is also earthed some other way (eg, via signal cables).

with extra panels and the addition of 12V or 24V batteries of small to large capacity. In my mind, the inverter is the key item here. Can Silicon Chip or any of its advertisers, provide reviews on suitable inverters that would allow us tinkerers to have a play and gain some valuable knowledge on the way? (T. G., via email).

- If you are thinking of running appliances like pool pumps and washing machines, you need the biggest inverter you can afford, preferably 2kW and above and it should have a good surge rating. You will also need a 12V or 24V battery bank because this sort of inverter is unlikely to be happy being simply fed by a solar panel. And the panel will need to be reasonably large; 20W would be nowhere big enough – it might only be enough to provide the standing current for the inverter!

How about bridged-T compensation?

For your Ultra LD Mk.3 Power Amplifier (Silicon Chip, July 2011), you used 2-pole compensation. I've just read chapter 9 of Bob Cordell's "Designing Audio Power Amplifiers" in which he comments that with conventional 2-pole compensation there is a large peak in loop gain within the audio band and that "such an anomaly in the open-loop

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Foiling A Tech-Savvy Youngster

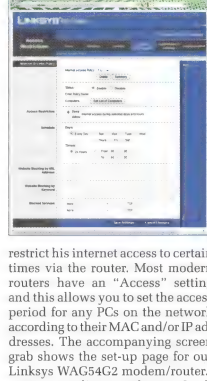
I have a 15-year old who has a habit of sneaking online and using Facebook or YouTube without permission. He is also too knowledgeable for me to simply pull his network line out of the router as he replaces it and then removes it when he is finished.

So, if I was to use some system of disconnecting him from the router without his knowledge, including leaving his network line plugged in (as this would really stump him), could I use some form of relay card and hide the connections so he cannot access them? Which would be the best line to switch through the relay?

Hopefully, I can cut just one of the conductors to prevent him from accessing the net when I'm away. I have already thought of editing his *hosts.sam* file but that means I then have to re-edit that file to reinstate access, something he already knows how to do.

If I can stump him completely, then he will have to admit defeat, especially if he sees me inputting a password etc to turn his network line back on. Your advice would be appreciated, if only to affirm that we old-timers still know more (and can be more devious) then the younger generation. (D. S., via email).

• Assuming that your son has his own PC, the easiest method is to restrict his internet access to certain times via the router. Most modern routers have an "Access" setting and this allows you to set the access period for any PCs on the network according to their MAC and/or IP addresses. The accompanying screen grab shows the set-up page for our Linksys WAG54G2 modem/router.



You can discover the MAC address (or Physical Address) of a PC by entering ***ipconfig /all*** at the Command Prompt.

Of course, if your son is really tech-savvy he could simply swap the modem/router when he needs access, assuming he can get his hands on another one and knows the DSL/cable password.

gain of the amplifier in the middle of the audio band is undesirable".

From your Bode plots on page 76 of the same issue, it appears that the peak is at about 3kHz for the Ultra-LD amplifier. His proposed solution is to use a third capacitor across the two existing capacitors. This would be approximately one-tenth the series value of the existing capacitors, which he refers to as "bridged-T compensation". This removes the peaking while maintaining the extra loop gain. For the Ultra-LD, the extra capacitor, based on his suggestion, would be about 10pF and would be connected between Q9's collector and Q8's base.

I'd be interested to hear if you agree that this is important and whether it might improve the amplifier. If so, could you try it and run some measurements to see how it affects the performance? While I'd love to try it myself instead and let you know, without an Audio Precision test set I'm unable to measure distortion low enough.

I realise it's a bit of an ask but I'm not in any hurry and I figured I'd at least ask the question. I've got two boards now but probably won't get around to building them up for a while.

Thanks for a great magazine and special thanks to Nicholas Vinen for all the excellent audio designs of late. (I. B., Hornsby, NSW).

• We don't think the spike in open loop gain is a problem; more open loop gain is generally better but the sudden open loop phase shift around 3kHz may be an issue as it reduces the effectiveness of feedback at higher frequencies.

We did not expect that putting such a small value capacitor across the network would make much of a difference but a simulation shows that it does. It lowers the open loop gain below 3kHz significantly and increases the phase shift but it also reduces the phase shift above that frequency. In essence, you're getting a feedback scheme which is a compromise between single-pole and 2-pole.

However, we don't think it will make much difference to distortion. We have concluded after working on the Ultra-LD Mk.3 extensively that the performance at low frequencies is extremely good and unlikely to be easily improved. On the other hand,

continued on page 112

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Ask SILICON CHIP

. . . continued from p110

the performance at high frequencies is limited by the PCB layout which, while excellent, doesn't give total cancellation of electromagnetic radiation. So it would require an extensive redesign and a lot of experimentation to make it much better (if we even could).

Having said all that, we don't think it would hurt to add a 10pF capacitor across the compensation network.

Reverse switch for 5-inch locomotive

I am going to use the 12V 10A Speed Controller (SILICON CHIP, June 1997) in a 5-inch gauge electric locomotive and was wondering if it was possible to incorporate a reverse switch in the circuit? My concern is with diode D2 and capacitor C3 across the motor terminals. Would I put the reversing switch before or after the diode and capacitor? I intend to use a double pole/double throw switch for the reverse. (J. A., via email).

- Place the reversing switch between the controller and the motor. The diode should be on the controller side, while the capacitor should be directly across the motor. Make sure the motor is stopped before changing the reverse switch position. SC

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Notes & Errata

Wideband Oxygen Controller Mk2 (June-August 2012): on the PCB, the anode of ZD1 does not connect to the adjacent ground track as it should. The PDF file on the website has been corrected to fix this.

If you bought a PCB from the first batch, bend the lead of ZD1 over and solder it to the negative (lower) pad of the adjacent 10uF capacitor or fit a wire link between these two pads. Ensure it can not come in contact with any other nearby pads.

Using Two PC Power Supplies for 24V (Circuit Notebook, August 2012): most PC power supplies have their output ground internally connected to earth.

For this circuit to work, one supply must have floating outputs. The low-voltage ground is normally earthed through one or more solder pads under the screw heads holding the internal PCB to the earthed metal case. Typically, the supply will still operate if these earth connections are broken (eg, by using insulating washers under the screw heads).

Do NOT disconnect the mains earth at the input socket as the metal housing must remain earthed, as should any EMI suppression components. Care must also be taken if a PC power supply is opened up as they contain large, high-voltage capacitors which can retain a lethal charge for some time and they often have exposed mains and high-voltage DC components.

Advertising Index

Agilent Technology 15
Altronics 88-91
Bitscope 77
Dyne Industries 9
Electronex 7
Element14 14
Embedded Logic Solutions 12
Emona Instruments 65
Front Panel Express 11
Geoff Coppa 111
Grantronics 111
Hare & Forbes ..... OBC
High Profile Communications 111
Instant PCBs 111
Jaycar IFC,53-60
Keith Rippon 111
Kitstop 109
LED Sales 111
LHP.NET.AU ..... IBC
Low Energy Developments 111
Matrix Multimedia 10
Microchip Technology 39
Mikroelektronika 69
Mouser Electronics 5
Oatley Electronics 97
Ocean Controls 101
ozQRP 111
Quest Electronics 111
Radio, TV & Hobbies DVD 87,109
Red Button Technologies 21
RF Modules 112
Rohde & Schwarz 13
Sesame Electronics 111
Silicon Chip Binders 51,111
Silicon Chip Bookshop 103
Silicon Chip Order Form 105
Silicon Chip Partshop 104
Silicon Chip Subscriptions 81
Siomar Battery Engineering 3,111
Soltronics 11
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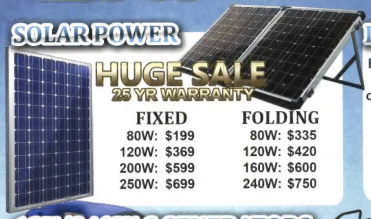

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